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CO-OPERATIVE MATHEMATICS.

Fletcher Durell,

Belleplain, N. J.

Many teachers of mathematics, either from personal preference, or because of curriculum and similar difficulties beyond their control, have been unable to go the whole length with the so-called general or fused mathematics. Yet almost all mathematical teachers who have seriously and earnestly studied and experimented with general mathematics, have learned many details from the method which they have been able profitably to use as modifications of the traditional method of teaching the different branches of mathematics separately.

The general result with such teachers has been a tendency toward a form of presentation which it is here proposed to name Co-operative Mathematics.

In co-operative mathematics, each branch, as arithmetic, algebra, geometry, etc., keeps its own individuality and organization, but at the same time it transfers from the other branches and welcomes to itself any detail which may be locally useful. It freely and aggressively uses such transferred material, provided always that the transferred part does not impair, but rather, if possible, aids the individual organization of the part to which it has been transferred.

The discussion of this matter which follows will relate especially to the problem of Junior High School Mathematics.

For instance, when written on the co-operative plan, a Junior High School Mathematical book would contain a distinct section on algebra, and such a section would be organized essentially in the traditional way. Thus there would be a treatment in succession of topics like the fundamental processes, fractions, equa-

tions, exponents; of equations as simple, fractional, simultaneous, quadratic; and so on. But to such an algebra section there would be a transfer of topics or parts of topics from arithmetic or geometry wherever convenient, such transfer however being made without any essential breaking up of the old customary order and relations of algebraic topics as outlined above.

For example, case three of percentage may be transferred from arithmetic and made a part of fractional equations in algebra. By case three is meant the case where a certain per cent of a number being given, it is desired to find the number, thus:

Ex. 1. If 8 per cent of a number is 21.76, find the number.

In algebra this problem is solved by use of the equation,

$.08x = 21.76$, *or* $\frac{2x}{25} = 21.76$

Ex. 2. Find the number which when diminished by 17% of itself equals 664.

Use the equation, $x—.17x = 664$

It is the writer's experience in teaching the subject of percentage in arithmetic, that the ordinary class has little or no difficulty with cases one and two, but that the addition of case three adds enormously to the troubles of the class, in fact, increases the number of failures in the topic three or four fold. Indeed, when taxed in this way, some pupils give up altogether, say they cannot learn the subject, and form a new distaste for arithmetic or even for mathematics as a whole.

On the other hand, when case three of percentage is transferred to algebra, it becomes an easy and interesting application of equations and an illustration of their value and power. In other words the topic is changed from a liability to an asset. At the same time instead of impairing the organization of algebra as a distinct discipline, it makes that organization more pronounced.

Similarly in the subject of geometry, the co-operative method would lead us to retain the customary succession of topics and the usual organization of subject matter, but would also enable us to introduce any mathematical principle already mastered that will add to the efficiency of our methods of work; provided always, that we do not impair the essential organization of geometry as an individual discipline or branch of study. This would lead to a free use in geometry of equations in their different forms, of the use of transposition, of negative numbers, of factoring, etc.

An instance of the helpfulness of such a practice is the simplification in some of the steps in the proof that the sum of the exterior angles of a polygon is equal to four right angles. At a certain stage in this proof we have the following steps:

(Sum of ext. $\angle$s)+(sum of int. $\angle$s) = ($2n$ rt. $\angle$s)

But (sum of int. $\angle$s) = ($2n$ rt. $\angle$s)—(4 rt. $\angle$s)

Subtracting (Sum of ext. $\angle$s) = (4 rt. $\angle$s)

The last of these steps is much easier to justify by the principles learned in algebra, than by the so-called axioms of geometry. In fact, in most texts in geometry, the step is not really proved at all.

A principle cause of the unreality and artificiality of much of arithmetic to many pupils is a lack of appreciation of the place value of the digits composing a written number. Thus, when questioned as to the relative value of the two 9's in 919, they may answer correctly that the left hand 9 has one hundred times the value of the right hand one, but they do not realize that if the 9 in the hundreds' place had a size proportional to its value (the units' 9 being taken as standard) it would be 6 inches long. Similarly in 919, 319, the last 9 would be so small as to be invisible.

Co-operative mathematics supplies convenient ways of remedying this defect in our number symbolism. For instance, one excellent way is to have pupils construct many graphs (essentially a use of geometry), especially bar graphs in connection with their numerical work. In time power should be acquired to draw such graphs free hand, till the unconscious habit is formed of picturing the values of the important numbers dealt with in something like their real size.

If the nature of co-operative mathematics is clearly grasped, it sometimes opens the way to an aggressive development of a transferred topic or principle, with reciprocal advantages to the branches concerned.

Thus, in the study of word problems (Ex. Express c yards d feet as inches; as feet; as yards) it is possible to review practically every arithmetical process and relation and to extend some of them in valuable ways, and thus to confer a deeper and more connected grasp of arithmetic as a whole. This also adds greatly to the interest of algebra and develops higher algebraic powers in the pupil.

In geometry many proofs and numerical computations are rendered much simpler by the free use of algebraic symbols on

diagrams. Pupils show a curious reluctance to this aggressive use of algebraic symbols on diagrams and to the subsequent use of algebraic processes in connection with the problem to be solved or the demonstration to be obtained. It is an excellent drill to take a page of mensuration problems, have pupils draw a figure for each problem, place on the figure the given numbers (or other data) in their proper places, to mark an unknown part by x, but to do nothing else till all the diagrams have been thus drawn. Such a drill is an item in the active use of co-operative mathematics.

As an illustration of how two of the three branches of elementary mathematics may be combined to throw light upon the other branch, we may take the following problem:

Ex. The cost of a certain concrete road was $72,000. Of this the county paid twice as much as the township, and the state paid three times as much as the township. Find how much each paid. Draw a bar graph of these amounts. What per cent of the entire cost did each pay? Draw a circle graph showing these per cents.

Such a treatment of a problem compels the pupil to form a real and many sided grasp of the problem and prevents algebra from degenerating into a mere juggling with symbols.

Another illustration of the co-operative use of the three main branches of elementary mathematics is the use of the other two branches to throw light on the geometry involved in the following problem:

Ex. An equilateral triangle, a square, a regular hexagon, and a circle all have the perimeter a. Obtain an expression for the area of each of these figures in the form of a^2 with a decimal or integral coefficient. Draw a bar graph to show the relative size of these areas. Find by what per cent each of the other areas exceeds the area of the triangle.

The following is a list of other items of co-operative mathematics, some of which are already in use to some extent:

(1) The transfer of the first treatment of the extraction of the square root of a number from arithmetic to the mensuration part of geometry.

(2) The transfer of the indirect cases in interest (finding time, rate, etc.) from arithmetic to the topic of formulas in algebra.

(3) The transfer of analysis with decimals and fractions from arithmetic to the topic of fractional equations in algebra. (Ex. If the cost of ¾ of an acre is $240, find the cost of an acre).

(4) The transfer of most of arithmetical ratio and proportion from arithmetic to similar triangles in geometry, and fractional equations in algebra.

(5) The free use of mathematical tables in all three branches. So of the use of graphs, formulas, and the function or variation concept.

(6) The further development of the algebraic and graphic-geometric aspects of logarithms, in connection with their number use.

(7) The use of numerical trigonometry in both algebra and geometry.

Certain other aspects and items of co-operative mathematics are more pervasive in nature and their adequate presentation would require more space than is here available.

In a subsequent article the advantages afforded by co-operative mathematics as compared on the one hand, with old time methods, and on the other with general or fused mathematics, will be discussed in a more systematic way.

EDUCATIONAL RESEARCH CLEARING HOUSE.

For the purpose of aiding universities, colleges, and other agencies in the elimination of wasted effort and duplication in the study of educational problems, the Bureau of Education of the Interior Department announced today the organization of a clearing house on current research work in education being conducted throughout the country.

Recent investigations have resulted in the discovery that in many institutions of higher learning and research organizations original studies into educational questions have been started by members of their staff or by students only to find that the same work was being prosecuted without their knowledge in other institutions or within the different departments of their own institution.

The clearing house is expected to terminate much of the lost energy and motion developed as a result of this situation. Organization of the new project has already been inaugurated by the Bureau. A comprehensive list has been made of all higher educational institutions and agencies engaged in original studies of educational questions or preparing works on such subjects. Requests are now being sent for copies of all completed and current educational researches being carried on by them. Upon their receipt the Bureau plans to publish at frequent intervals descriptions, reviews, and abstracts of these studies showing the institutions where they are being pursued.

Through the establishment of this type of clearing house, all educational research agencies will be in a position to obtain first-hand information on research work in education and in arranging for new studies will be enabled to ascertain whether they are duplicating studies being conducted elsewhere.

The work connected with this project will be performed by the present staff of the Bureau of Education in addition to their other duties.

HIDE AND SEEK WITH RADIUM.

By R. L. Doan,
Development Engineer, Western Electric Co.

A few months ago fifty milligrams of radium were lost during the treatment of a patient in a hospital at Milwaukee, Wis. Since the radium was insured, the owner immediately notified the insurance company of the loss and the company in turn telegraphed its representative in Chicago to secure the services of someone competent to make a search for the valuable material. A matter of some five thousand dollars was involved and the need for prompt action was imperative. In view of the simplicity of apparatus and manipulation required to locate such a highly radioactive substance as radium it is a rather astonishing fact that about ten places in Milwaukee and Chicago were tried before anyone was found who would consent to make the search. Inasmuch as several high schools were included in the number of places tried, it is thought that a brief discussion along this line may prove of interest to some of the readers of School Science and Mathematics. Such a discussion may also be useful to those teachers of physics who are on the lookout for experiments which will add to the interest of the laboratory work. A few simple experiments with easily obtainable radioactive substances, requiring only an electroscope and perhaps a micrometer microscope are well within the possibilities of a high school course and never fail to hold the interest of the students. The writer is of the opinion that more experiments of this sort might well be substituted for some of the time-honored members of the usual laboratory curriculum.

The property of radium which renders it so useful in the treatment of certain tissue diseases and which, incidentally, is also responsible for our being able to locate the material in case of loss, is its property of disintegration. The disintegration consists in the spontaneous explosion of an atom, whereby one, or two (or both) kinds of "bullets" are sent out, sometimes accompanied by a flash of light. The "bullets" are positive and negative charges of electricity and the flash of light, the so-called gamma radiation, is akin to x-rays in its nature. After the explosion the remains of the radium atom may spontaneously "go off" again, shooting forth more electric charges, and this process continues, altho with widely varying lengths of times between explosions, until a stable condition is reached. Indeed, it is one of the disintegration products of radium, the inert gas

radium emanation, rather than the radium itself which emits the penetrating radiation useful in the treatment of disease. Once this gas is driven away from the radium (by the application of heat), the latter has none of the powers ordimarily attributed to it until more of the emanation is formed in the natural process of transformation. This process requires about a month to reach equilibrium, altho most of it is completed in a day or so.

If the "rays" emitted by a radioactive substance be allowed to traverse an air path the air is rendered a conductor of electricity. This is accomplished by the simple process of ionization in which a neutral air molecule is knocked apart into two oppositely charged components which move in opposite directions under the action of an electric field. It is by means of this important property of the rays that we are able to detect the presence of radium or other similar substances. The method is explained below.

If an electric charge is given to a gold leaf electroscope the leaf will stand out in a more or less stationary position, depending chiefly upon the quality of insulation as to how immobile it will be. However, even when the insulation is perfected to a high degree there will still be a slow continuous downward movement of the leaf, and this constitutes what has been called the "natural leak" of the instrument. A micrometer microscope, focussed on the gold leaf, is required to determine quantitatively the amount of the natural leak, which may conveniently be expressed as the time required for the leaf to move over five divisions of the microscope scale. Now a small quantity of radioactive substance brought into the vicinity of the electroscope will cause the leaf to move downward more rapidly, due to the discharging effect of the atmospheric ions produced by the active radiation emitted by the substance. This difference is easily detected by means of the microscope even when the movement is too small to be noticeable by ordinary visual observation. The rate at which the leaf will fall depends upon the quantity of radium present, its distance from the electroscope, and the size of the ionization chamber. With a chamber of about a liter capacity and an ordinary low power microscope one can usually detect the presence of five milligrams of radium within a radius of eight or ten feet. If no microscope is available it is an easy job to construct an electroscope with a much larger ionization chamber, and it may even be desirable to do this in any event. A large (five gallon) tin can may be used for this purpose, the

rod with leaf attached being inserted in a hole thru the lid and insulated from it by a piece of amber. Glass windows for observation can be put in the sides of the can. An impromptu device of this kind was used successfully a few years ago to locate a quantity of radium which had accidentally been thrown into a sink and got lodged in the underground drainage pipes a half block away.

For use in therapeutic work radium is stored either in five milligram needles or twenty-five milligram capsules. It was two of these capsules which got lost at the Milwaukee hospital. Because of the small size of these containers, especially the needles, they are easy to overlook and it happens more often than one might suppose that they are lost track of altogether. When the insurance companies are notified of the loss they always call upon someone who knows how to manipulate an electroscope so that a complete search can be made for the radium before a settlement is made on the policy. One of the most fruitful places to try in a case of this kind is the furnace or incinerator, as the radium needles often stick to bandages and are thrown with them into the waste. It is necessary to exercise considerable caution in examining ashes so as to be sure not to overlook anything. If the fire has been hot enough to melt the containers then a double caution is necessary, because if the search is made too soon after the fire dies down a negative test with the electroscope may not be conclusive evidence of the absence of radium. This is because of the fact, mentioned previously, that the active gas, emanation, is driven off by the application of heat and is formed again only rather slowly. However, it is safe to make the test twenty-four hours after the fire goes out.

GENES AND GENOMERES

Just as the atom, the standard "indivisible particle" of the earlier chemistry, has been split up into electrons, so the gene, the standard carrier of a given hereditary quality, is now split into new subdivisions called genomeres, to satisfy the requirements of phenomena which the orthodox genetical concepts of the present day can not explain.

At the Fifth International Genetics Congress at Berlin, Prof. William M. Eyster of Bucknell University told how his studies of variegations, or contrasting colors appearing in the leaves and flowers of plants, led him to the adoption of the genomere hypothesis. The standard concept, that genes were indivisible hereditary units, could not account for these strippings and spottings, and the only thing to do was to think of the genes as cut up into sub-units, which usually hang tightly together, but which on occasion can come apart and re-arrange themselves. When they do this, they form a sort of genetical mosaic, which expresses itself in the mosaic appearance of the plant itself.—*Science News-Letter.*

BOTANY IN HIGH SCHOOL AND COLLEGE.*

By J. E. Kirkwood,

The University of Montana, Missoula, Mont.

It is now some sixty years since botany began to find a place in our universities. Before that time so few were the opportunities to find employment in botany that Professor Gray at Harvard advised the late Dr. Farlow, who had applied to him for professional training, to study medicine first so that he might have the means of a livelihood. In this condition evidently lies the reason why so many of our earlier botanists, and zoölogists too, were professional men, earning a living as physicians, lawyers, ministers of the gospel, or in other vocations, while they took from their regular duties as much time as could be spared for the study of the flora of their region or locality.

In the '70's, however, the study of botany began a more rapid development both at home and abroad. There had been a period devoted especially to the descriptive phases of the science. Great areas of the country were new, the settlement of the west was going on, and the impetus naturally was toward the fascinating revelations that came from every expedition. The first step in the sciences is naturally an effort at classification and organization, a work which in botany is still in a condition of vigorous progress. But the German universities opened up new branches of the subject; physiology and structure and life histories of plants became absorbing themes. In the '80's and '90's, many American students took graduate degrees there and returned to make over botanical instruction in the United States. From that time the teaching of systematic botany has waned and the emphasis has fallen upon the other lines accompanied by the great development of laboratories and equipment. Textbooks have multiplied in all but the oldest and most fundamental branch of the science, which now is represented mostly by manuals or floras of this region or that.

While we have gained in insight into the nature and life of plants by the new studies, we must, I believe, recognize that we have lost something of value in the incentive to interest which naturally comes with acquaintance with the native plants of field and forest. There are signs that we are coming back to an

*Read before the meeting of the Inland Empire Science Teachers' Association, Spokane, April 1927.

appreciation of systematic botany, which is not merely the naming of plants but a study of their genetic relationships, and so of their evolution, and one of the best means of learning the laws of inheritance and variation.

A recent study[1] of enrollment in botany in 25, mostly eastern, colleges shows a decline in numbers from 1916-1919 with a gradual rise from 1919 until the present. In 1918-1919, there was a sharp decline in total enrollment of these institutions due to the war. From 1918 to the present time has been a rapid increase in total enrollments. In 1916 the ratio of botanical enrollment to total registration was the highest it has been in 14 years. It was then 6-12 per cent, whence it fell to 5-7 per cent in 1919 and rose again from 8 to nearly 12 per cent in 1922. In Montana, at the University, the enrollment in botany for the present year varies from 13 to 15 per cent of the total enrollment of the institution. The number of institutions is too small to yield dependable averages, but aside from the figures, the evidence from other sources seems corroborative.

In the high schools, according to Hunter,[2] there has been a falling off in the last 10 years as to the number of courses in botany offered, a fact explained by the absorption of a large part of elementary botany into courses in general biology and general science. In such cases the teaching of a few lessons in botany by a teacher untrained in the subject could hardly be expected to lead to much appreciation of botany on the part of the students. Another series of figures recently published shows that botany leads over zoölogy when presented alone by a ratio of more than 2 to 1 in the United States, which seems to indicate a preponderance of interest in the plant side of life.

Results of our own studies of a year ago on the distribution of subjects in high school curricula in the four northwestern states show the following facts. Of 27 schools in Montana offering general science 5 include botany; in 6 general science courses reported from Idaho botany had no place; in 7 reported from Oregon there was one in which botany received notice; in 35 from Washington there were 6 including botany. Of 290 schools which were represented in our study 249 or 84 per cent gave courses in general science with total registration of 12,770 stu-

[1]Grier, N. M., A Preliminary Report on the Progress and Encouragement of Science Instruction in American Universities and Colleges, 1912-1922. SCHOOL SCIENCE AND MATHEMATICS 26: 753-764; 872-881; 931-940. 1926.
[2]Hunter, G. W., The Place of Science in the Secondary School. The School Review 33:370-381; 453-466. 1925.

dents. Of these 249 schools, however, only 75 so defined their courses as to assist us in this analysis. It is assumed, however, that these 75 were fairly representative. The courses in general biology showed a more equitable distribution of interest among the 179 schools offering the subject, 45 reporting from Montana, 13 from Idaho, 8 from Oregon and 44 from Washington. In most of these schools the course in biology consisted of botany and zoölogy equally divided, but in some physiology was included and the time usually divided equally between the three branches. Of the 290 schools, 62 per cent or 179 offered general biology, but only 110 stated the distribution of subjects. The registration in biology in the four states totaled 6,832. In botany alone there were 40 schools of the 290, or 14 per cent, but the registration was 2,905. Thus while the number of schools presenting botany was less than 23 per cent of those giving general biology the number of students enrolled was over 42 per cent. In zoölogy the number of schools was 16 or 6 per cent of the whole with a total registration of 892 or about 13 per cent. Thus there are more than three times the number of students in botany than in zoölogy, and less than half as many as in general biology.

Motives leading to the study of botany in high school and college may be examined briefly. In the questionnaire of a year ago, inquiry was made as to the teacher's objective in connection with the course in botany. About 54 per cent gave information, or the cultural value, as their aim. Discipline, or the scientific method, was the objective of 25 per cent, while the remaining 21 per cent assigned a vocational purpose. Many, however, failed to specify, possibly either failing to interpret the question or being in doubt as to what answer to give. As to its method, the study of botany does not differ greatly from other sciences, hence its disciplinary value need not be discussed here. In its vocational bearings it is either direct or indirect. The number of those finding a professional career as botanists is on the increase with the growing number of teaching positions, of experiment stations in agriculture and forestry, of research foundations, and of industrial enterprises dependent upon plant products. Specialization is growing and the call for experts in rubber growing, fruit raising, nursery practice, plant breeding, seed testing, ecology, pathology and other occupations outside of teaching are annually becoming more numerous and remunerative. From the conditions of sixty years ago when there were only three botanical professorships in the country to the present

with its abundant and growing opportunity is very gratifying and significant progress. The better positions paying $4,000 a year or more, offer a comfortable, dignified and enjoyable life work. Most young people are still unaware of these opportunities.

The indirect vocational interest is found in agriculture, forestry, landscape gardening, home economics and other spheres where botany and other sciences are fundamental in the preparation but are secondary to the professional practice. The so-called service courses given by botanical departments to students of pharmacy, forestry and other departments constitute a considerable part of the enrollment in college. Moreover, the prediction is justified that this line of instruction will increase in the high schools. Forestry and other professional 4-year curricula are becoming over crowded with the more technical subjects, which will mean inevitably that the elementary science courses on which they are built will be pushed down into the high school and become part of the entrance requirements for the professional schools. The only other alternative is the extension of the vocational training into post-graduate university work, which in the present outlook seems very improbable.

What will such shifting of elementary science courses downward mean to the high school? Much every way. It will call for preparation in botany along specific lines; in other words, standardized courses. It will mean equipment adequate for the work. It will mean definite preparation for the teachers of botany. Furthermore and incidentally, it will mean enhanced appreciation of the subject by producing stronger courses of study and better equipment and methods, and by demonstrating the practical value of botanical science do much to dispel the present popular indifference toward the subject, and so render a service to the public. In turn it will react also to the advantage of the college courses by creating a wider interest in the science and making possible its more thorough treatment in the higher institution.

Another reason for the study of botany is in its informational or cultural content,—cultural both in its body of knowledge and in its aesthetic and its philosophical lessons. Nowadays, one can hardly claim a liberal education while ignorant of the significance of so wide-spread a phenomenon as the green in vegetation, of Mendelism, of the relations of the major groups of plants to the geological past, or of the broad general controls and mean-

ing of geographical distribution. The aesthetic and philosophical bearings of the science in relation to art, literature, religion, sociology, morality, health, and other interests as seen in the facts of variation, inheritance, evolution, survival, resistance, response, and many other phenomena of the plant world, are too weighty to be discussed in this brief period, but a little reflection will show their far-reaching significance. It is with this value in mind as well as the importance of a knowledge of the scientific method in general that leads most universities to admit botany as one of the several sciences required for the bachelor's degree. As the sciences differ in their history and content so their following among students differs according to their special appeal to this mind or that, or according to prerequisite requirements of departments. Such requirements should be made on the basis of what contribution the subject makes to the intellectual background of the student, as when courses in botany and zoölogy are required of students seeking a degree in education. That these courses should be required may be a debatable question, but when one is required to the exclusion of the other, as occurs in one western university, it seems very ill-advised indeed. The lessons taught by both botany and zoölogy are so deep and far-reaching that no prospective teacher could fail to gain in sympathy, in insight, and in power, by learning of the science of life in which he is going to deal in its highest and most crucial form in the childhood and youth of the land.

In the close crowding of the modern college curriculum and the multiplicity of opportunity and necessity, it is impossible to gain even a smattering of all the sciences in the allotted 4 years. This condition is leading to survey courses which aim to present the fundamental contributions of the sciences to human welfare and progress. What will soon be demanded are courses that interpret the facts of science in terms of moral and social obligation.

In conclusion, a few things may be suggested which have a bearing on the mission of the teaching botanist. The prosperity of our science in the school and the community rests with us, not with the students nor with the public. The justification and the reward of our work which are due us will not come until we are aggressively conscious of the value of our subject in its relations and significance.

One of the things which the successful teacher must do is to clarify his objective. He must know why he is teaching the

science and what he is trying to accomplish. One of the impressions gained from the replies received in our studies was that many teachers did not know why they were teaching this or that science and that apparently the only definite reason was the salary. If in our analysis of the subject we can believe in its human values within and without the school and vision the future and our share in its making through this particular task, I believe we shall catch the inspiration that leads to success.

Finally I would say that the larger place to be occupied by botany in the public interest will depend upon the initiative of those who are occupied with it. Just as medicine, the ministry, engineering, and other activities, which bulk large in affairs of today, are such because of the power and industry of their representatives, so the botanist must make a place for himself and occupy it. He can do this only by showing the world that what he represents is necessary to its interests and only in proportion as he succeeds in this will his place be enlarged. There is nothing in waiting for this place, we must go after it.

COLD INCREASES IMMUNITY.

That the varying resistance put up by men and animals to toxic shock by bacterial poisons and other foreign substances introduced into the blood may be due to the temperature of their surroundings, is indicated by the studies of Prof. E. Friedberger, director of the Research Institute for Hygiene and Immunity at Berlin.

Dr. Friedberger made parallel tests of the toxic effect known to scientists as protein anaphylaxis, using in one series animals kept in unheated cages at from 38 to 42 degrees Fahrenheit, while in a second series the temperatures were those of an ordinarily comfortable living room. He found that the animals kept in the cold held out against doses of the poison 150 times as great as the quantity needed to kill their companions that had lived in the warmth.

Prof. Friedberger calls attention to the practice followed by some physicians, of keeping patients afflicted with infectious diseases, as well as soldiers with dangerous wounds, in unheated booths or stalls exposed to the outer air, rather than in well-warmed hospital wards. This practice has been wholly empirical, but these experiments may be the foundation of a rationale for such procedure.—*Science News-Letter.*

NEW DIABETES TREATMENT.

Another diabetes treatment has been announced. Dr. Karl von Noorden, professor of medicine at the University of Frankfort, reports a new substance for the treatment of diabetes which he calls "glukhorment" made from the pancreas by a process of fermentation. It has the practical advantage over insulin of being given by mouth rather than by injection and clinical tests of the new preparation are being awaited with interest in medical circles.—*Science News-Letter.*

LABORATORY UNKNOWNS IN GENERAL CHEMISTRY.

By Lyman J. Wood and Seward E. Owen,

St. Louis University, St. Louis, Mo.

The usual course in beginning chemistry requires the student to perform experiments, the results of which are for the most part known from the beginning. Such experiments, which we might call descriptive in nature, while essential in many cases, do not in general stimulate the curiosity of the student. Because of a lack of interest, the student frequently makes a note book record that has no particular relation to his experimental work, the material in the note book, of course, describing the results which he knows he is expected to get. In some cases probably no experimental work is done at all.

In order to avoid these and other difficulties described by one of the authors in a recent paper (Lyman J. Wood, Jour. Chem. Ed. Vol. 3, p. 1313, 1926), a number of unknowns have been devised to take the place of or accompany a considerable portion of the usual descriptive experiments in freshman chemistry. These unknowns have been found to stimulate interest and also to afford opportunity of adapting the laboratory requirements to the ability of the individual student since in many cases some of the unknowns can be made more difficult than others.

A few years ago the assignment of more difficult work to some students than to others would have been considered as unfair and might be so considered by some teachers even now. However, it is believed by the authors, as well as others, that a certain minimum amount of work should be required of all students and that above this minimum not more work, but a higher type of work should be required of the students of greater ability.

The United States government recognizes difference in physical size when issuing army uniforms. The quartermaster is, accordingly, supplied with three types of uniforms, i. e., "longs," "shorts" and "stouts." There are about eight different sizes of uniform to each type, and therefore approximately twenty-four chances of fitting a uniform on a man. It would be foolish indeed to expect to fit the same sized uniform, or even the same type of uniform, on every man entering the army. Possibly the mental calibre of students in college may be even more varied than the physical sizes of men in the army. It would seem almost equally as foolish to expect to fit a uniform inflexible chemistry course on all students as to try to fit the same uniform on all men

entering the army, except as circumstances make it unavoidable.

Some effort has been made to recognize this difference in mental calibres in developing the series of laboratory unknowns in general chemistry, described below. It has been found possible in many cases to devise a series of unknowns for a given experiment which require widely varying student abilities. In this way independent work is required of each student and also the calibre of work required may be made, at least to some extent proportionate to the ability of the student.

Unknowns.

Some of the unknowns used in our course are listed and briefly described below. Doubtless many others might be added so that the needs of any teacher of chemistry could be met.

Quantitative Unknowns. (1) "Determination of grams per cc of an unknown wooden block." The purpose of this experiment is to become familiar with the metric system of measurements. The block is carefully measured and weighed and the results are reported and the instructor checks the figures by a table of known dimensions. Although this determination is very simple it has not been found to be without value to most beginning students.

(2) "The determination of grams per cc of an unknown metal." Different lengths of rods and tubes of such metals as iron, lead, copper, zinc, tin, and nickel are issued. The student weighs the metal sample to the nearest centigram and obtains the volume by displacement in carbon tetrachloride in an alkali burette. His reported findings are checked by the instructor as in the previous experiment.

(3) "The determination of per cent of oxygen in an unknown." The student knows the unknown to be either potassium chlorate or potassium perchlorate and is asked to determine the per cent of oxygen and incidentally to determine whether he has chlorate or perchlorate. The unknowns are issued ready mixed with powered manganese dioxide in the ratio of three parts of unknown to one part of maganese dioxide.

(4) "Determination of number of grams of sulphur to unite with one gram of an unknown metal." The student knows his unknown to be one of two metals as nickel or copper, iron or nickel, nickel or lead, etc. The metal is issued in the form of a powder mixed with an equal quantity of sulphur. A weighed amount of the sample is heated to complete the reaction and the excess

of sulphur is distilled off. The weight of sulphur per one gram of metal is determined and incidentally the formula of the sulphide is calculated. Pairs of metals whose atomic weights are nearest to each other are reserved for the better students.

(5) "Determination of the number of atoms of chlorine to unite with one atom of a metal sample." The student obtains a sample of metal and dissolves it in aqua regia. The solution is then evaporated to dryness and the weight of chloride formed is determined. Cadmium has been found to be an admirable metal for this determination. Table one shows the results obtained by a small class under carefully controlled conditions during the past summer.

TABLE ONE.

Showing the number of atoms of chlorine for one atom of cadmium obtained by several beginning students.

Student's laboratory number	Atoms of chlorine per atom of cadmuim
1	1.91
2	2.05
3	1.99
4	1.91
5	1.90
6	2.23
7	1.99

The average figure for the number of atoms of chlorine for one atom of cadmium is well within the limit of experimental error.

(6) "Determination of the normality of an unknown acid solution." Each student makes up an alkali solution whose strength is approximately two normal and then standardizes this solution by adding an excess of hydrochloric acid, evaporating the solution and weighing the amount of salt formed. The original alkali solution is then diluted and titrated against the unknown acid. Individual unknowns are readily made up by mixing measured amounts of five normal acid and water from two burettes.

(7) "Quantitative determination of the amount of oxygen in a gaseous mixture by the use of alkaline pyrogallate." The procedure for this experiment varies from the usual only in that the student obtains from the store room an unknown mixture of nitrogen and oxygen in a test tube over water. The unknown mixture may be ordinary air, air enriched with oxygen or air enriched with nitrogen.

Qualitative unknowns. (8) "The properties of a pure substance." An unknown is provided which is either a pure sub-

stance or a mixture. The student must perform distillation, crystallization, solubility and evaporation tests and report whether he has a pure substance or a mixture. Some of the materials used for this experiment are listed in table two.

TABLE TWO

Showing composition of unknowns which students must prove to be a mixture or a pure substance.

Ingredients	Key letters (given to students)
Water	an
Chloroform	ol
Salt	gr
Sulphur	mn
Water and salt	he
Sulphur and salt	wi
Water and alcohol	sk
Lead chloride with potassium chloride	xy

(9) "Determination of the conductivity of solutions." The student is supplied with several solutions or substances to be put into solution. He places these successively in a beaker and immerses in the solution two electrodes arranged in series with an electric lamp on the regular lighting circuit. If the lamp lights there is conductance. Any carelessness on the part of the student in washing beakers or electrodes between tests is easily detected when the unknown is reported.

(10) "The chemical tests for the halides." Three unknowns are issued to each student in numbered test tubes as is illustrated in table three. The use of numbered test tubes makes the possible number of different unknowns quite large. If M denotes the number of permutations of n things taken p at a time it is known that

$$M = n(n-1)\ (n-2)\ (n-3) \ldots\ldots (n-p+1)$$

and in this case M equals 24 but if combinations including more than one similiar unknown are used the possible number of different unknowns mounts to 64.

No one tube contains more than one halogen except in the case of some of the better students. These unknowns follow a series of preliminary work on the halides. In our laboratory the non-halogen mixtures usually contain phosphates or carbonates or both. With acid the carbonate liberates a gas and with silver nitrate the phosphate gives a yellow precipitate similar to the halides; this precipitate, however, is soluble in nitric acid. Such unknowns tend to keep the student constantly on the alert.

TABLE THREE

Showing method of issuing halogen unknowns

Student's Lab. Number	Tube 1	Tube 2	Tube 3
1	Cl	Br	I
2	Br	Cl	I
3	Br	I	Cl
4	I	Cl	Br
5	I	Br	Cl
6	Cl	Br	X[1]
7	Cl	X[1]	Br

SEMI-UNKNOWNS.

As a means of giving individuality to the work, at the beginning of the year, a laboratory number is assigned to each student. In certain experiments, as for example in the work on Boyle's law the student uses a volume of air which is related to his own laboratory number. Each student thus obtains a set of data that is not duplicated by others and to a certain extent, his problem is individual. It has been found that the laboratory number gives a new interest to such experiments and that the psychological effect produced by its use is excellent.

THE CHECKING OF RESULTS.

While in the case of many experiments unknowns can be issued and in the case of some of the descriptive experiments results are produced which can be preserved for inspection, it has been found expedient to check some experiments at the time of performance. An instance of this sort is to be found in the experiment in which the solubility of hydrogen chloride is determined by forcing a drop of water into an inverted flask of hydrogen chloride connected to a beaker of water by means of a glass tube. It is expected that the water will rush into the flask until it is almost filled. The most common error in this experiment is the use of a wet flask, in which case the water does not rush into the flask. It is a regrettable fact that neither the failure nor the cause of the failure is a source of worry to many students. The student simply writes down the results which he observes on the desk next to him and perhaps draws a careful picture of the geyser and never suspects the cause of his own failure.

[1]X represents a non-halogen.

Means of checking this type of experiment at the time of performance has been found in the simple expedient of arranging the students' laboratory numbers on a card of vest pocket size such as is shown in table four. At the point of work where the student is about to force the drop of water into the flask, he calls the instructor's attention. In one or two seconds the experiment is a success or a failure. If it is a failure tbe instructor does not check the student's laboratory number and the work must be repeated. In our laboratory students have been known to make as many as five or six attempts before realizing the importance of a dry flask.

Limits of Experimental Error.

In all experiments involving the use of quantities the student must be allowed a wide range of experimental error for he is a crude, unskilled manipulator at best. Some professional schools

Table Four

Showing instructor's vest pocket checking card for use in sight checking student laboratory results.

1	16	31	46	61
2	17	32	47	62
3	18	33	48	63
4	19	34	49	64
5	20	35	50	65
6	21	36	51	66
7	22	37	52	67
8	23	38	53	68
9	24	39	54	69
10	25	40	55	70
11	26	41	56	71
12	27	42	57	72
13	28	43	58	73
14	29	44	59	74
15	30	45	60	75

multiply the beginning students' chances of success by increasing the size of the sample, thus, while the absolute unavoidable error remains the same for a large sample as for a small one its relative influence on the results is less in the case of the large sample. In one dental school with which the authors are familiar, the beginning dental students are first required to carve teeth four times the size of a normal tooth, from a block of plaster of paris. Cavities are then made in this large tooth similiar to the ones which are later to be made in normal sized teeth. Thus a beginning student may obtain satisfactory results even though

he be an unskilled worker using a crude method of procedure, if the size of the sample taken be large enough.

In the case of the unknowns described above it has been found possible to limit the unavoidable expermental error due to weighing to 1% or 1.5% and at the same time use centigram balances. This has been accomplished by increasing the usual size of the sample. The centigram balances used are of the triple beam type (no loose weights) and have been found to be more satisfactory than milligram balances because: (1) Only a small interval of time is required to make a weighing; (2) There are no fractional weights to be mixed or lost; (3) Their use requires less skill; and (4) The cost is only a fraction of the cost of reliable milligram balances.

Summary.

1. The unknowns include both quantitative and qualitative types and are usually preceded by descriptive work.

2. The plan presented suits the difficulty of the laboratory work to the abilities of the students.

3. The student's interest is stimulated by the necessity of doing individual work on his assignments.

4. The student is required to obtain results which the instructor knows to be acceptable and the note books are records of actual accomplishments and are not mere copy books.

WE APOLOGIZE TO DRAKE UNIVERSITY.

Due to misinformation, we erroneously reported in our October number that Drake University had combined with Des Moines University and the new institution had fallen into the hands of the Fundamentalists. For this report we tender our sincere apology and call the attention of our readers to the fact that Drake University has not changed its organization and has no connection whatever with Des Moines University. Drake University has long been a leader in progressive education and thought and under the able leadership of President D. W. Morehouse will no doubt continue to be one of the foremost educational institutions of the mid-west.

We trust that all our readers will assist us in correcting the false impression given in our previous news item.

A DISCUSSION OF SOME OF THE PRINCIPLES UNDERLYING RAINFALL.

By Hiram W. Edwards,
University of California at Los Angeles.

An examination of some twenty popular texts and reference books dealing with Physics, Geography, Physiography and Weather has revealed the fact that a complete and accurate description of the principles underlying the formation of rain is not included in the descriptions of this important natural phenomenon. It is the purpose of this article to merely point out some of the pertinent principles and to make a few remarks about some of these. The principles referred to are listed here in a summarized form:

1. The heat from the sun supplies the necessary energy for converting water into water vapor.

2. Winds are caused by differences in air pressure.

3. The moisture-carrying capacity of air depends upon its temperature.

4. Expanding gases become cooler because the work done by expansion is accomplished at the expense of the heat content of the mass.

5. Ions necessary for the deposition of water from supersaturated gases are practically always in sufficient abundance, because of the ionizing property of short electromagnetic waves or the cosmic ray (Millikan).

6. Air, carrying water vapor, becomes slightly supersaturated if cooled below its dew point.

7. Drops of water large enough to fall may be formed from the deposition of water by condensation upon small droplets or by a coalescence of several smaller droplets.

To this list there should be added at least one other principle, —one which describes the formation of regions of low barometric pressure. At present, so far as I have been able to find out, no complete explanation of this process is available.

While some of these principles are included in the books above, the main objection is the description of the process by which the air is cooled to the dew point. Such statements as the following are made. "The moist winds carry the water to cooler places and therefore become cooler." "The moist winds run into cooler currents of air." "The air rises and cools because it comes into cooler air higher up." Again the statement is made

that the warm moisture laden winds blow against cold mountains and is cooled thereby. There is, of course, an element of truth in these statements and undoubtedly rains may be formed occasionally by just such causes but by the very nature of these cooling factors, the resulting rainfall must in general be limited to insignificant areas. Such an explanation applied to a case where the rain falls over a region 1000 miles long by several hundred miles wide is obviously absurd. For cases of such extensive rainfall the cause of the cooling must be due to the expansion of the air. In all probability such expansions occur in general during horizontal movement of the air masses as the air is moving towards the region of lower barometric pressure, although near the center of the low pressure area upward movements with consequent expanison must also occur.

On the windward side of mountain ranges there is usually an excessive rain formation due to cooling by expansion. Expansion in such cases is caused by two factors—upward movement and pressure decrease horizontally. The mountains act like the clothes wringer so that the descending air masses on the leeward side have a comparatively low humidity. In such cases the descending air experiences an increase of pressure and hence an increasing temperature due to compression.

Millikan's work with the cosmic rays has shown what is probably the most active source of rain drop neuclei. One result of his work is that the cosmic rays are of very short wave length, much shorter than the gamma radiation of radioactive substances. He has also shown that there is a considerable decrease in the intensity of this radiation with decreasing elevation. The absorption of the cosmic ray is accomplished by secondary radiation and ejection of electrons from the absorbing elements. Secondary radiation will cause the ejection of other electrons which combined with the ionizing power of high speed electrons seems to furnish an abundant supply of ions for the neuclei of rain drops.

The fact that there is some relation between sun-spot activity and world weather has been experimentally indicated. Whether this activity is responsible for the origin and movement of areas of low barometric pressure has not been established as far as the writer is aware. It has been clearly shown by C. G. Abbot of the Smithsonian Institution that sun-spot activity and intensity of solar radiation are related. A report of this investigation was given at the Washington meeting (April 25-27) of the National

Academy of Sciences. This research shows that higher solar radiation is associated with increased sun-spot activity, and that there are definite periods of activity. Although the observations have not been extended over a long enough extent of time to find the complete law of cyclic variation, there is evidence of sufficient importance to warrant further work which will probably lead to valuable and accurate methods of forecasting. Such work as this does not establish any connection between movement of areas of low barometric pressure and sun-spot activities but does rather shift the connection to the energy relation. Perhaps we may soon be able to extend our first principle to include a definite statement of the quantitative variation of the amount of energy received by the earth, and hence the cyclic variation of rainfall.

When our students recognize in the phenomena of rainfall the operation of familiar principles, they (as adults) will be less subject to the preying attacks of so-called "rain-makers," and will assist men of science in their efforts to remove from the popular mind the last traces of superstition concerning the weather.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

Being some observations of the great and near-great on the nature of the several sciences and on the art of living in general, preserved occasionally without prejudice but reproduced always with mental reservations.

By Duane Roller.

In the earliest ages science was poetry, as in the latter poetry has become science.—*James Russell Lowell.*

Today the goal of the scientist is not an impossible perpetual motion machine but rather the efficient utilization of the available energy of the universe and that increase in availability which may follow further knowledge as to the composition of matter. Scientifically the aims are radically different, but socially they are identical, for in both cases the aim is to lift man above the struggle for existence.—*John Mills, American engineer, in The Realities of Modern Science, 1919.*

I love fools' experiments. I am always making them.—*Charles Darwin.*

Everyone who enjoys thinks that the principal thing to the tree is the fruit, but in point of fact the principal thing to it is the seed.—Herein lies the difference between them that create and them that enjoy.—*Fredrich Wilhelm Nietzsche, German philosopher, in Maxims.*

Blessing on Science! When the earth seem'd old,
When Faith grew doting, and the reason cold,
'Twas she discover'd that the world was young,
And taught a language to its lisping tongue:
'Twas she disclosed a future to its view,
And made old knowledge pale before the new.

—*Charles Mackay, Scottish poet.*

CERTIFICATION REQUIREMENTS OF TEACHERS OF SECONDARY SCHOOL SCIENCE IN CERTAIN SOUTHERN AND BORDER STATES.

BY DR. W. W. CARPENTER,

George Peabody College, Nashville, Tenn.

Boards of education and high school principals sometimes assume that any teacher can teach anything within the high school. Universities and Teachers Colleges sometimes assume that all of their students will teach in schools where they will be required to teach only one subject.

Information relative to the number of subjects taught by our science teachers is found in a recent study by Finley[1] which says:

> We are led to conclude that approximately 10 percent of our science teachers teach but a single subject; 30 percent teach two subjects; thirty, three subjects; twenty, four subjects, and 10 percent teach 5 subjects in the high school.

That science teachers are teaching subjects for which they have not prepared is indicated by a recent study[2] which points out, that of the 230 Minnesota science teachers considered, the following percents were prepared in the subject they were teaching:

Chemistry	50.9	Zoölogy	15.7
Physics	16.1	Physiography	3.4
Botany	13.5	Physiology	0.4

With such a large percent of our science teachers unprepared it is important that we try to discover the cause and if possible suggest a remedy. The problem will therefore consider the different agencies that concern themselves with the certification of teachers. This will include a study of the requirements of selected state teachers colleges of the Southern and Border states[3], a study of the State Universities in these same states, a study of the certification requirements in these same states, and a study of the requirements of the regional accrediting agency, the Southern Assn. of Schools and Colleges.

We will first consider the science required by the Southern

[1]Finley, Chas. W. The Training of Science Teachers. SCHOOL SCIENCE AND MATHEMATICS. Vol. XXVI, No. 4, p. 406, April, 1926.
[2]Hutson, P. W. High School Science Teachers. A Study of their training in relation to the subjects they are teaching. *Educational Administration and Supervision*, IX: 423-38, 1923.

[3]Thirty-six State Teachers Colleges of the Southern and Border States were selected for this study. The list follows. They are not arranged in the order of Table I. This study is based upon the offerings as indicated in the latest catalogues. All comparisons are made in terms of quarter hours.

Association of those schools preparing science teachers. The Southern Association does not attempt to prescribe what science courses shall be offered in any of the schools attempting to prepare science teachers. The standards[4] published in 1926 merely state:

STANDARD 2.

a. The college should require for the general arts and sciences degrees and for the bachelor degree in education, the completion of 120 semester hours of credit (or the equivalent in term hours, quarter hours, points, majors or courses), with further qualitative requirements adopted by each institution to its condition.

b. Not more than one-fourth of the credits required for graduation should represent professional subjects.

c. All subjects offered for degrees in four year courses shall be of collegiate grade.

STANDARD 11.

The laboratory equipment shall be adequate for all experiments called for by the courses offered in the sciences, and the facilities shall be kept up by means of an annual appropriation in keeping with the curriculum.

The following schools are included in this study:

1. Arkansas—Arkansas State Teachers College, Conway.
2. Georgia—State Normal School, Athens.
3. Georgia—Georgia State Woman's College, Valdosta.
4. Kentucky—W. S. T. C. and Normal School, Bowling Green.
5. Kentucky—E. K. S. T. C. and Normal School, Richmond.
6. Louisiana—Louisiana State Normal College, Natchitoches.
7. Mississippi—State Teachers College, Hattiesburg.
8. Missouri—S. E. Missouri State Teachers College, Cape Girardeau.
9. Missouri—N. W. Missouri State Teachers College, Maryville.
10. Missouri—S. W. Missouri State Teachers College, Springfield.
11. Missouri—Central Missouri State Teachers College, Warrensburg.
12. Missouri—State Teachers College, Kirkville.
13. North Carolina—East Carolina Teachers College, Greenville.
14. Oklahoma—East Central S. T. C., Ada.
15. Oklahoma—North West State T. C., Alva.
16. Oklahoma—South East S. T. C. Durant.
17. Oklahoma—Central State T. C., Edmond.
18. Oklahoma—North East State T. C., Tahlequah.
19. Oklahoma—South West State T. C., Weatherford.
20. Tennessee—East Tenn. State Teachers College, Johnson City.
21. Tennessee—West Tenn. State Teachers College, Memphis.
22. Tennessee—Middle Tenn. State Teachers College, Murfreesboro.
23. Texas—Sul. Ross State T. C., Alpine.
24. Texas—West Texas State T. C., Canyon.
25. Texas—East Texas State T. C., Commerce.
26. Texas—North Texas State T. C., Denton.

[4]Standards of Southern Association of Schools and Colleges, 1926.

27. Texas—Sam Houston State T. C., Huntsville.
28. Texas—South Texas State T. C., Kingsville.
29. Texas—S. W. Texas State T. C., San Marcos.
30. Virginia—Radford State Teachers College, East Radford.
31. Virginia—State Teachers College, Farmville.
32. Virginia—State Teachers College, Fredericksburg.
33. Virginia—State Teachers College, Harrisburg.
34. West Virginia—Concord State Normal School, Athens.
35. West Virginia—Fairmont State Normal School, Fairmont.
36. West Virginia—Marshall College, Huntington.

This paper is not attempting to solve the question as to whether or not the accrediting association should determine the amount of science and science education that prospective science teachers should take: it does however wish to point out that the association is not now making any quantitative requirement of prospective science teachers, either as to science courses or as to science education courses. In fact the requirements as stated are so general and so much freedom is given that there is little hope that with the present rule, trained teachers of science would be developed if this agency were the only agency whose demands would have to be met by the prospective science teacher. There seems to be no prospect, in the immediate future, of this standard being revised.

Our next attempt to discover some standard that determines what science and science education the prospective science teacher shall study leads us into a consideration of the requirements of certain selected teachers colleges and the state universities in the same states.

What are the specific requirements that the teachers colleges have made that will insure that those who will teach science shall be well prepared in subject matter and method? Do these requirements demand preparation in minor fields as well as major fields? Is any provision made requiring science of all students or are only those who have selected scienee as their life work, required to study it? How do the requirements of the teachers colleges compare with those made in the state universities in the same states? Answers to these questions are found in a recent unpublished study[5] by Alonza M. Donnel and Carl G. Campbell of George Peabody College for Teachers. Their results are given below as Table I and Table II.

Table Number 1 is divided into two parts. Part A—indicates the minimum science requirements for the different degrees offered by the Teachers' Colleges. Twelve of these schools do

[5]Campbell, Carl G. and Donnel, Alonza M. Minimum requirements in science for graduation from 36 Teachers Colleges and the 12 State Universities in 12 Southern States.

not offer the A. B. degree. The range in science requirement of those offering this degree is from 0 to 24 hours. Two schools require no science, the mode is 9 hours. Four of these schools offer an A. B. in Education. Two of these require no science and one requires 9 hours, the other 4.5 hours. For the B. S., the range is from 0 to 46.5 hours. Nine hours and fifteen hours each appear 7 times. Three schools require no science. For the B. S. in Education the range is from 0 to 37.5. Two schools require none; 7.5 and 9, occurring an equal number of times. There are a total of 9 schools or 25 percent where one standard

TABLE I.

Minimum requirements in science for graduation from 36 Teachers Colleges in 12 Southern and Border States.

	PART A.				PART B.			
	Hours of Science required for degree				Hours required for			
Teachers College	B.A.	B.A.Ed.	B.S.	B.S.Ed.	Major	Minor	Minor	Gradtn.
1.	—	0	—	—	36	18	.....	189
2.	—	0	—	36	Prescribed course			198
3.	9	9	—	—	Prescribed course			216
4.	18	—	46.5	—	36	18	.....	199.5
5.	—	4.5	—	4.5	36	27	.....	192
6.	15	—	—	—	(2) 15 each			200
7.	—	—	12	—	36	24	24	192
8.	7.5	—	7.5	37.5	37.5	22.5	.....	180
9.	7.5	—	15	7.5	37.5	22.5	.....	180
10.	7.5	—	—	7.5	22.5	22.5	.....	180
11.	9	—	—	9	36	18	18	180
12.	—	—	—	0	33.75	27.5	15	180
13.	9	—	—	—	Prescribed course			196
14.	12	—	15	—	36	18	.....	180
15.	12	—	15	—	36	18	.....	180
16.	12	—	15	—	36	18	18	180
17.	12	—	15	—	36	18	.....	180
18.	12	—	15	—	36	18	.....	180
19.	12	—	15	—	36	18	.....	180
20.	—	—	0	—	36	27	18	192
21.	—	—	0	—	36	27	18	192
22.	—	—	0	—	36	27	18	192
23.	9	—	9	—	36	27	18	180
24.	18	—	18	—	36	27	18	180
25.	9	—	9	—	36	27	18	180
26.	9	—	9	—	36	27	18	180
27.	9	—	9	—	36	27	18	180
28.	9	—	9	—	36	27	18	180
29.	9	—	9	—	36	27	18	180
30.	—	—	—	9	36	18	.....	187
31.	—	—	—	0	Prescribed course			180
32.	—	—	9	—	36	27	18	186
33.	—	—	—	18	27	27	.....	186
34.	24	—	—	—	45	24	.....	192
35.	0	—	—	—	36	24	.....	192
36.	0	—	—	—	30	22.5	.....	192

—means that the degree is not offered.

NOTE:—All hours have been corrected to *quarter hours*.

degree may be earned without the study of any science unless the student elects to major or minor in science.

Part B indicates the hours required of majors and minors and the total hours for graduation. There are ten schools from the 36 which require 36 quarter hours for a major, 27 quarter hours for a first minor and 18 quarter hours for a second minor. If a student selects one field of science as his major we may be assured with these requirements that he will be well prepared in this field. There is more than a strong possibility that he will be prepared in two science fields and a possibility that he will be prepared in three science fields. The requirement is not generally accepted that these minors must be in the field of science.

Table II is divided into Part A and Part B as was Table I. This table considers the State Universities in those states where these selected teachers colleges are located. Under Part A it is observed that six of the universities, or 50 per cent, grant one or more standard degrees which reouire no science. Three of these six each offer two standard degrees that require no science.

Part B indicates the quarter hours required of majors and minors and the total hours for graduation. Two of these universities require 36 hours for a major which is the modal requirement for the teachers college major. When these two schools are compared as to majors and minors with the most frequent occurrence of majors and minors for the teachers colleges, we note that one requires more of its minors and one requires less. In terms of the major requirement there are four universities which require more and 6 less than the modal requirement for the teachers college major. Taken as a whole there is more similarity in the requirements between the universities and teachers colleges than there is difference.

The teachers college does make a somewhat better showing than the University in the percent of schools offering standard degrees without science. Only twenty-five percent of the teachers colleges offer such degrees while fifty percent of the universities offer such degrees. The significance of this offering is noted when it is pointed out that our teacher training institutions are preparing science teachers in two ways. The first way is with a selected group of people who expect to teach at least one science and who, upon completion of their course, are well qualified by training to do so. The second way is with a group of people who will teach science but who do not elect it in college or are not required to take any of it in college. Their only train-

ing for science consists in studying subjects that are not science. Among this group are probably many who prepared for one branch of science but find that they have been assigned to teach another branch for which they have had no training. That this group must be large in number, is shown by again referring to the study made by Hutson in Minnesota. It seems self evident that there should be no teachers, teaching science who have not been trained in science. Should we expect our teacher training schools to require a minimum of science of all students and by so doing aid in eliminating the untrained science teacher?

TABLE II

Minimum requirements in science for graduation from 12 State Universities in states where 36 representative Teachers Colleges are located.

	PART A. Hours of science for degree				PART B. Hours required for			
	B.A.	B.A.Ed.	B.S.	B.S.Ed.	Major	Minor	Minor	Gradtn.
1.	0	—	99	0	49.5	40.5	40.5	186
2.	0	18	54	—	27	18	....	207
3.	0	9	90	36	36	36	21.5	190.5
4.	21	—	51	117	27	18	....	216
5.	18	27	48	27	27	18	18	195
6.	0	—	—	0	24	15	....	180
7.	12	12	—	—	20	10	....	180
8.	0	—	30	0	42	24	24	186
9.	9	—	84	12	84	....	....	201
10.	18	—	—	18	36	18	18	180
11.	18	—	36	—	90	....	....	180

NOTE:—All hours are converted to quarter hours

We find no definite science requirement for science teachers by the Southern Association. Loopholes occur in the requirements of our training institutions such that teachers may teach branches of science for which they have not been trained. The colleges require far more of their students than the Association asks them to require and yet for reasons mentioned our science teachers are still unprepared. Our study will now consider state certification of high school science teachers. What, if anything, is state certification doing to remedy this situation? Of the three agencies the regional accrediting agency, the teacher training institution and the state certifying body which is now doing the most to insure trained science teachers? To which of these three agencies may we look for immediate aid?

Answers to what the state certifying agency is doing may be obtained by a study of Table III.[6]

[6]Only the states in which the 36 state teachers colleges were located are considered here. This information was obtained by personal correspondence with the state superintendents or their assistants. Answers were received from all except three. Information relative to these was obtained from the latest accessible state reports.

It is noted, that in general, a college graduate (with approximately 18 hours of education) is certified that he is qualified to teach high school subjects. There is not a uniform requirement accepted by even 50 percent of these states that if a teacher is to be a science teacher he should study science and science education. It is very hopeful however to observe that some of these states have already passed such regulations that are now in effect, others have passed regulations which will go into effect in the near future and others have changes under serious consideration.

One of our very progressive southern states is not included in this table for the reason that none of the thirty-six teacher colleges were located in that state and this table is limited to the states in which these schools are located. However, information from this state was obtained and is given at this time because it illustrates a move in the right direction. Their requirement is:

1. The minimum requirements for the issuance of a general academic certificate, are twenty-four semester hours in the major subject and eighteen hours in the minor subject. While it is understood as a matter of administration that a person holding a certificate issued on this basis will not be assigned to teach in any field other than that covered in the major and minor, a teacher could be assigned to teach science on this certificate who had neither majored nor minored in that field.

2. These requirements can be met only by the satisfactory completion of courses in colleges and universities.

Even in this excellent regulation however there is a small loophole, which, may of itself *guarantee* to the poorer district a teacher who has neither majored nor minored in science.

Another interesting question arises in considering the rule for state No. 9. Eighteen hours of science are required. However, it is not specified whether these shall be physics, chemistry, biology, geology, etc. with the result that there still remains a big loophole. A teacher may take all his work in one field or fields and satisfy the requirement and yet be assigned to teach one or more *fields* of science that he has not studied. Attention is called to the fact that a situation like this cannot arise with the regulation of state No. 6.

TABLE III.

Science requirements in certificate regulations for science

teachers of certain of the Southern and Border states.

State *Science requirement*

1. Little relation between the certificate one has to teach and the training which one has to teach a certain subject.
2. No requirement. Recommended that those expecting to teach a certain subject major in that subject to the extent of 18-24 semester hours.
3. No requirement.
4. No minimum requirement in science.
5. No requirement at present. Hope for change soon.
6. Minimum of seven and one-half semester hours credit in each course taught, or five hours in each course taught and five hours in a closely related science and a two-hour course in the teaching of high school science.
   Minimum requirement for general science. Fifteen semester hours in science with a minimum of five hours in physical science and five hours in biological science and a two-hour course in the teaching of high school science.
7. None at present. A very desirable plan will become effective about July, 1928; this contemplates the issuance of a high school teacher's certificate for science and mathematics based on training.
8. No requirement.
9. Eighteen quarter hours of science required. Does not specify branches of sciences.
10. No requirement.
11. Two years of college science required of those expecting to teach science.
12. No subject matter requirement. Local schools select on basis of subject matter.

In comparing the efficiency of these three agencies in securing for us trained science teachers at present, the teachers training institutions take first place, because they do require definite science work of those who *know they are to be science teachers.* But if we are looking toward the agency which will give us aid immediately we must select our state certifying body. In the last analysis the question of trained teachers for the science subjects depends on the requirements set up by the different state certifying agencies, generally the State Board of Education.

If we accept the principle that education is the function of the state, then we must take the next step and admit that it is also a function of the state to require that every teacher in the state shall have had training in the subject or subjects that he is teaching, including the different science subjects.

The immediate remedy suggested, for our large percent of unprepared science teachers, is to accept this principle in fact as well as in theory. It is to our state certifying bodies that we look for immediate aid.

ON THE THEOREMS OF PAPPUS.

By Raymond Garver,

University of Rochester, Rochester, N. Y.

The average Calculus text gives little emphasis to the two theorems of Pappus, which are concerned with the relation of volumes and surfaces of revolution to centroids. Of the half dozen with which I am best acquainted, Cohen (Differential and Integral Calculus) has the only complete discussion. Phillips devotes some space to the theorems, but with rather incomplete proofs. Love (Differential and Integral Calculus) and Woods and Bailey (Analytic Geometry and Calculus) state them only as exercises, Woods and Bailey not even attributing them to Pappus. Osgood (Introduction to the Calculus) and Granville seem not to mention them.

And the authors who mention the theorems apply them in only a very small number of cases. Love asks the student to use them in finding the volume and surface of the torus, the centroid of a semi-circular area and arc, and the centroid of a right triangle. And these seem to be practically the standard examples.

One purpose of this paper is to suggest the introduction of the theorems of Pappus, not only as interesting relations, but also as actual tools in doing problems of the types ordinarily proposed in calculus texts. To illustrate, let us consider the second theorem:

If a plane area is rotated about an axis in its plane which does not cross the area (this is a convenient, though not strictly necessary restriction), the volume generated is equal to the product of the generating area and the circumference of the circle described by its centroid.

There are two types of volumes of revolution which can be treated conveniently by use of this theorem. First, we may know at least one coordinate of the centroid of an area from symmetry, and may thus be able to obtain a volume almost immediately. The example of the torus is the common illustration, but there are other cases where the theorem is just as effective. Consider the volume obtained by rotating the first arch of the sine curve around the Y-axis. For a case of this kind the theorem becomes $V=2\pi\,\bar{x}A$, where A is the generating area and $\bar{x}$ is the x-coordinate of its centroid. Assuming that the student has done area problems before coming to volume problems, and

uses his previous results, the volume is obtained at once as $2\pi(\pi/2)2$ or $2\pi^2$. And for the volume obtained by the similar rotation of the first arch of the cycloid (taking the parametric equations, as usual, so that this arch cuts the X-axis at O and $2\pi a$, and $\bar{x}$ is consequently πa), we have $V=2\pi(\pi a)(3\pi a^2)=6\pi^3a^3$. In cases of this kind the work is ordinarily much simpler than if we set up and evaluated the necessary integral.

In other cases I find the theorem useful, not because there is any particular saving in work, but because it serves as a unifying influence is a set of problems concerned with the same area. For instance, Love has this problem (page 160, No. 5):

Find the volume generated by revolving the area under the curve $y=e^x$ from $x=0$ to $x=1$ (a) about OX; (b) about OY; (c) about the line $x=1$.

If the student is using the ordinary methods of integration he is almost certain to regard this as consisting of three distinct problems; there are three integrals to set up, although there is of course a close relation between the latter two. But if he uses the theorem of Pappus, he looks at the example as a single problem, consisting of three similar parts. Briefly, the work would be arranged as follows, denoting the three volumes of the example by subscripts,

$$A=e-1, \quad \bar{x}=\frac{1}{e-1}, \quad \bar{y}=\tfrac{1}{4}(e+1),$$

$$V_1=2\pi\bar{y}A=\frac{\pi}{2}(e^2-1),$$
$$V_2=2\pi\bar{x}A=2\pi,$$
$$V_3=2\pi(1-\bar{x})A=2\pi(e-2).$$

Similarly, when the student has once found the centroid of the area bounded by a parabola, the X-axis, and an arbitrary ordinate, he is in a position to solve a considerable number of problems. For instance, Woods and Bailey (page 289, No. 61) require the volume generated by rotating the area bounded by $y^2=8x$ and the ordinate $x=2$, around the line $x=3$. The average student seems to have some difficulty in setting up the integral for the evaluation of this volume, but the theorem of Pappus gives a direct solution. Suppose that the student has already derived the following general results: the area bounded by $y^2=ax$, the X-axis, and the ordinate at $x=b$, is equal to $\frac{2}{3}a^{\frac{1}{2}}b^{\frac{3}{2}}$; the x-coordinate of the centroid is $\frac{3}{5}b$; the y-coordinate of the centroid is $\frac{3}{8}a^{\frac{1}{2}}b^{\frac{1}{2}}$. We then have for the example, A (the total

area bounded by the parabola and the ordinate) is equal to 32/3, is $\bar{x}$ equal to 6/5, and $V=2\pi\ (3-\bar{x})A=38\ 2/5\pi$. Of course for this particular problem we did not require $\bar{y}$.

A similar theorem of at least equal usefulness can be derived easily for pressure problems. When I first developed the theorem and gave it to a class of mine I was unaware that it appeared in print. I find now that Woods and Bailey have it as an exercise, but I have seen it nowhere else, and it certainly simplifies the average pressure problem immensely.

If a vertical area is submerged in a liquid, the pressure is given by a definite integral. In a pressure problem I find it convenient to take the vertical axis as the X-axis, with the positive direction downward, and to take the Y-axis at the surface of the liquid. If the area is bounded by the X-axis, a curve $y=f(x)$, and the ordinates at $x=a$ and $x=b$, the pressure integral is $w\int_a^b xy\,dx$, where w is the weight per unit volume. We can then state the theorem:

The pressure on a vertical area submerged in a liquid is equal to the product of w, the area, and the depth of its centroid.

If the area is of the type mentioned above the proof is immediate. For $A\bar{x}=\int_a^b xy\,dx$, and we have $P=w\bar{x}A$. The proof can be easily extended to other areas. Actually in most of the pressure problems ordinarily stated the vertical area can be placed symmetrically with respect to the X-axis, and the centroid is on the X-axis. Further, its exact position is usually easy to find. I shall conclude the paper by stating three pressure problems, with their sources. The reader may be interested in comparing the solution by the above theorem with the usual solution by integration.

I. (Cohen, 316) Find the pressure on the side of a vertical flood-gate in the shape of an isosceles triangle whose base is 6 feet and whose altitude is 4 feet, if its vertex is 12 feet below the surface of the water. (The vertex is supposed to be the lowest point of the triangle.)

Since the area is 12, and $\bar{x}=28/3$ (the centroid of any triangle is at the intersection of the medians), we have at once $P=112w$, or approximately 7000 pounds.

II. (Phillips, Integral Calculus, 71) Find the water pressure upon a semi-circle of radius 5 feet if its plane is vertical and its diameter in the surface of the water.

The area is $25\pi/2$, and $\bar{x}$ is $20/3\pi$, since for any semi-circle in the same position, $\bar{x}=4r/3\pi$, r being the radius. We then

obtain $P = 250w/3$.

III. (Love, 283) Find the total pressure on one face of a square 2 feet on a side, submerged with one diagonal vertical and one corner in the surface.

We secure immediately $P = 4\sqrt{2}\, w$. And to find the pressure by integration it is necessary to set up and evaluate two separate—integrals.

TIRED?

By A. Schaeffer, Jr.

"Just one more round," is one of the best-known phrases in Americana. To the loser it means hope, to the cartoonist it means a new idea, and for many a wife it means another hour of sentry duty.

To the doctor, however, it means "fatigue" and the many diseases to which it opens the way, such as heart, kidney and nervous diseases, chronic digestive disturbances, and tuberculosis. Curiously enough, the most terrible of these diseases is the one that may be arrested most readily if it is discovered in time. It is tuberculosis.

The National Tuberculosis Association, which has been combating this disease for many years, says that fatigue is the entering wedge in practically every case. The fatigued body has a greatly reduced resistance to diseases in general, but to tuberculosis in particular, because so many persons carry tubercle bacilli about in their bodies in a dormant state. The deadly germs await only the opportunity to become active; so a chronically tired person is a ready-made victim.

Fatigue also has its mental aspect, for the exhausted worker is very likely to become the negligent father who has little will-power or energy left to interest himself in the details of family life and to maintain standards of conduct which make for decent home life. A lowered standard of living, which is bound to follow, is conducive to disease, so it is not uncommon for tuberculosis workers to find, in such a sub-standard family, that the father has an active case of tuberculosis, while several of the children have contracted it from him. A single such family, if they remained undiscovered, may infect others in the community in which they reside, by careless disposition of their sputum, promiscuous spitting and failure to cover their faces when coughing or sneezing—at the factory, in school, on street cars or busses, in stores, theatres, and movies—all because one man carelessly let fatigue get the better of him.

Tuberculosis workers, in seeking out such families—and there are an astounding number throughout the United States—are protecting the entire community. The local tuberculosis association for which they work is a voluntary, unofficial organization supported by the sale of Christmas seals each December. They protect YOU.

The morals are two: Avoid fatigue all year round; and, buy Christmas seals in December.

Granting of scholarships to students primarily because of athletic ability has been abolished at Pennsylvania State College by the new board of control of athletics of the college. The ruling takes effect this fall, and after three years no student athlete at the college will receive any financial aid what ever. Action was also taken by the board prohibiting "scouting" of any form on the playing of rival teams.—*School Life.*

AN INVESTIGATION OF THE TEACHING OF SCIENCE IN THE JUNIOR HIGH SCHOOL.

By Emma Osborn Thompson,

West Philadelphia High School.

The Junior High School has grown so popular and the number of schools has increased so rapidly during the past few years that the work it is doing has become a real factor in our school system, one that should be given serious consideration.

In order to ascertain the standing of science in the Junior High School today, its place and relative importance in the curriculum, the time given to it, the manner of teaching, the text book used, the variation or uniformity in the procedure, a questionnaire was sent in March 1924 to Junior High Schools in cities of the first, second and third class in the United States.

The questionnaire was sent with a letter to the Principal of Junior High Schools in cities listed by the Department of the Interior, Bureau of Education, Washington, D. C., in the City Leaflet No. 12, September, 1923.

Twenty-two letters were sent to cities of Group I, cities having a population of 100,000 and over.

Seventeen replies were received, or 77.27 per cent.

Twenty-seven letters were sent to cities of Group II, cities having a population of 30,000 to 100,000.

Twenty-two replies were received, or 81.48 per cent.

Thirty-six letters were sent to cities of Group III, cities having a population of 10,000 to 30,000.

Twenty-one replies were received, or 58.33 per cent.

Summary.

	Number of Schools Receiving Questionnaire	Number of Schools Replying	Percent of Schools Replying
Cities of Group I	22	17	77.27
Cities of Group II	27	22	81.48
Cities of Group III	36	21	58.33
Total	85	60	70.59

38 of the 48 states in the United States are listed as having Junior High Schools.

While replies have been received from 34 states, they have not

been received from a city of each class in these states.

SUMMARY.

	Number of Schools Replying	Number of Junior High Schools	Percent of Junior High Schools
Group I	17	16	94.11
Group II	22	21	95.45
Group III	21	15	71.42
Total	60	52	86.66

Following is a copy of the questionnaire that was sent out:

1. In what grade or grades is science taught?
2. What science is taught?
3. Is science required or elective?
4. How many periods a week are given to science?
5. What is the length of the period?
6. What number of pupils work in the Laboratory at one period?
7. Does each student do individual Laboratory work?
8. Do you use the project method?
9. Do you conduct field trips in connection with your class work?
10. Do you visit industrial plants?
11. Do you use a text book?
12. Name of text book?
13. Does each student keep a note book?
14. Are diagrams and charts required of the students?
15. Do you have a Science Club?

Certain facts are made apparent by a summary of the replies.

(a) It is customary to teach Science in the Junior High School: 87% of schools answering questionnaire are Junior High Schools; 94% of Junior High Schools answering the questionnaire teach Science.

(b) Science is taught in all three grades: 40% teach science in 7th grade; 71% teach science in 8th grade; 67% teach science in 9th grade.

(c) It is the practice to require science, though in many schools science is required only in the 7th and 8th grades and elective in 9th grade: 76% of schools make science a required subject; 24% of schools make science an elective subject.

(d) Altogether 18 different subjects have been classified as science, of these 11 can properly be called science, since they are generally classified thus in the curriculum: 78% teach General Science; 15% teach Biology. The other sciences are scattered, so that we conclude that it is decidedly the custom to teach General Science.

(e) There appears to be greater agreement in the periods per week, 5 periods predominating: 52% teach science 5 periods per week; 19% teach science 4 periods per week; 15% teach science 3 periods per week; 15% teach science 2 periods per week.

(f) The length of the period varies, ranging chiefly from 40-50 minutes. However, there are some schools that have one hour periods, and other only half-hour periods: 50% of schools have 40-50 minute period; 21% of schools have 60 minute period; 6% of schools have 30 minute period.

(g) The range in pupil load per class varies from 20 to 45, but the small class predominates: 58% of classes reporting as working in the laboratory have 20-30 students.

(h) Many of the schools report that they have no laboratory facilities, two stating that the students do laboratory work at home: 71% have no laboratory facilities; 29% have experimental work in laboratory.

(i) In practically all the schools the project method is used entirely or in part.

(j) Field trips and visits to industrial plants are fairly general, an indication of the splendid attitude of the teacher: 69% of the schools go on field trips; 59% of the schools visit industrial plants.

The larger cities seem to have better organized Junior High Schools, but everywhere there are great differences and a lack of uniformity in the procedure. But while there is lack of uniformity, there is apparently no lack of good work, as indicated by the extra effort that is made by the teachers for their classes in organizing science clubs, etc. The greatest handicap would seem to be the lack of laboratory facilities.

Everywhere there is a wide awake and healthy attitude towards the problem of the teaching of science in the Junior High Schools. Certain schools where no science is taught, indicate that they hope to make it part of the curriculum, others desire and intend to offer more science.

IMPROVEMENT IN EXAMINATION TECHNIQUE FOR TEACHERS OF BOTANY.

By H. M. Jennison,
University of Tennessee, Knoxville.

(Concluded from November)

Constructing the Examination.

In the course of our experiments with the newer examination we have been rather explicitly guided by the suggestions and practices of professional workers in the fields of education and psychology. A most helpful book on the subject of "Improvement of the Written Examination" is that of Ruch recently published. Even more recently Russell and Paterson have brought forth works of similar scope and usefulness to that of Ruch's. Papers published earlier were found helpful but none is cited because the best of them and many others are listed in both books.

To date no standardized test in botany has been published so ar as I know. The biologrint are ts siety pnnot suitable for ourf needs. From the beginning of our experience we have been able to devise objective tests that fit our courses and our plan of teaching and I believe we have constantly improved them.

The steps in constructing an objective examination are several. Full directions will be found in the works of Paterson, Ruch, Russell and other educational psychologists. The few suggestions given herewith are considered essential.

As in traditional practice the scope of the examination will have been determined in advance, whether the class is notified or not. Next, the assignment should be studied with the idea of selecting the most important facts appearing in the topics included. If the assignment is an extensive one covering for example several chapters in a text-book, one's best judgment will have to be exercised in order that unimportant topics be not included at the expense of those which have been emphasized and are really important. When one has been discussing the subject matter assigned for the examination, it is a relatively simple matter, otherwise not. Painstaking procedure would call for a jotting down of the topics decided upon as being important.

Now having carefully determined the topics deemed to be of sufficient importance to include in the examination, a series of ordinary questions may be formulated and these turned into one or another of the type forms e.g., true-false, multiple-choice, com-

pletion and so on, such as are commonly used in objective examinations. If among other things a particular structure has been studied closely by the student, if knowledge of the anatomy of an organ has been especially emphasized in one way or another; or if some important figure or illustration warrants special emphasis, it is well to make a diagram of the structure or organ and call upon the student to label it fully. In other words, the material should be worked over into one or another of the several test forms according to the best judgment of the examiner, as to which one is most suitable for handling it without distortion. Several types of tests can be employed in one examination. We use five or six different types as a rule. This has the advantage of breaking up monotony of the examination and it gives all members of the class the fairest sort of chance, since some react better to one type than another. After the assignment is covered and the items all formulated those of the same mechanical type can be thrown together to constitute the separate tests of the examination. While carrying out the last operation the items in each test should be arranged in approximate order of difficulty, the most difficult items being placed last. By so doing the examination comes to possess greater accuracy and consistency as a measure of the student's knowledge of the subject. At this point it may be stated that, in actual practice we always advise the student being examined to proceed as rapidly as possible answering each item in the order given but not to spend an excessive amount of time puzzling over any one that is not known at first reading. Such points as these may later be considered more carefully when the whole test is again gone over.

Finally, the decision must be made as to the amount of time to be allowed for taking the examination. Assuming that the time allowed for taking the examination is limited to one hour, deductions having been made for explanations, announcements and the like, it is then necessary to determine as accurately as possible the number of items to be included. Experience with the use of the objective type of examination is highly desirable in this connection. In this paper we quote the recommendations made by Ruch who has observed and experimented with this factor. He states that "the number of items which can be covered by a pupil in a unit of time can be stated approximately for pupils of given ages and grades. These recommendations are at best approximate and depend greatly on the subject matter and degree of difficulty of the items.

HIGH SCHOOL OR COLLEGE STUDENTS AND ADULTS.

Recall type	4 to 8 items per minute.
Recognition type	6 to 10 items per minute.
True-false	10 to 15 items per minute.

The rules are based upon the use of items of such difficulty that the average student will get about half the items attempted correct, and the time limits are arranged so that about 90 per cent of all the students will have opportunity to attempt every item. It is further assumed that responses are to be indicated by the writing of a single word or short phrase, or by underscoring or by some simple rapid device. True-false examinations are generally not reliable unless one hundred or more questions are included."

It is doubtful whether our experience warrants the giving of further specific suggestions as to the construction of the examination. The teacher will find additional rules in the books cited in this paper, as well as in the many published papers on this subject. Further than this, only experience will provide an increased knowledge of methods of procedure and facility in the building of these examinations.

SCORING AND GRADING.

The prevailing custom is to mark the essay-type of examination on a percentile scale. Where letter grades are given these usually represent percentile values. When the traditional examination is used marking done on this basis seldom measures accurately the accomplishment of the student; nor does it form a measure of the difficulty of the examination. Obviously it is fairer to rate the student according to this achievement in relation to that of all other members of the class, rather than what may variously be regarded as perfection. Another way is to rate the student according to achievement each in relation to his own ability but this involves the use of more statistics than are usually at hand so we have been rating the individuals according to the first plan. In other words, we have found it advisable to adopt a standard for marking which makes it possible to interpret achievement according to a reliable standard.

The actual steps in the procedure of scoring an examination and grading the students may be somewhat as follows: First, the several tests composing the examination must be gone through by the teacher and a correct master form or key constructed for each. Where the items composing the test are mimeographed and arranged as in the illustrations a strip of white cardboard or

heavy white paper is placed opposite the answer blanks on the test sheet and the correct answers written upon it exactly opposite the blanks where the answers should appear. A separate and correct key, or the equivalent, is prepared for each test. Armed with correct keys the instructor or even a clerk can score the examination. In scoring, the incorrect answers are checked.

The component tests of the examination are checked separately and where practicable different persons may be assigned the task of checking and scoring separate tests. When all the papers are checked each test is scored. Where no attempt is being made to do more than obtain a simple measure of achievement of the several members of a class the further steps in scoring and marking are quite simple. At any rate, we have made it a practice to score the separate tests composing an examination in the same way, the score made on each test being C minus W = S, where C is the number of items correctly answered, W, those wrong and S, the score. Where long true-false tests are used it seems advisable to deduct two points for each item missed. This is done in order to overcome the possibility of poorly prepared students guessing the correct answers to a fairly high percent of the items. In the other types of tests this is usually unnecessary. When each test is scored the total or "raw" score earned by each individual is determined by totalling the scores made on each test. We find a sheet such as the one shown herewith (Illus. 7) convenient for this as well as other purposes, the same being attached as a front page of the examination.

Table 1.

Score Frequency and Grades

Score	*Number*
80—69	
68—67	
66—65	/ /
64—63	/ /
62—61	/ / / / (8) A
60—59	/ / / / / / / /
58—57	/ / / / / / /
56—55	/ / / / /
54—53	/ / / / / / / / / / / (31) B
52—51	/ / / / / / /
50—49	/ / / / / / / / / / / /
48—47	/ / / / / / / / / / / / /
46—45	/ / / / / / / / / / / / /

With the raw scores of all the class available, further correlation of achievement amongst the class is quite as possible as it is desirable. What is called "score frequency" is now deter-

44—43	///// ////		
42—41	///// ///	(62)	C
40—39	/////		
38—37	///// /////		
36—35	/////		
34—33	///// /		
32—31	//		
30—29	/////	(32)	D
28—27			
26—25	///		
24—23	/		
22—21	/		
20—19	//		
18—13			
12—	/	(8)	F

mined. This may be done in several ways as is shown by Russell or Pressey and others. A simple and sufficient method is to set down in columns the series of numerals corresponding to the perfect or highest score possible on the examination and continuing down to the numeral which corresponds to the lowest score made.

Each score is then tallied opposite the proper number as shown in the chart (Table 1).

When such a chart has been completed the relative achievement of individual members of the class may be readily visualized. We find it desirable to go further and translate the raw scores into letter grades. As in many educational institutions we attempt to separate the class into smaller groups by recognizing variations in achievement and character of the work done by individuals composing the class. With us:

A denotes excellent work; a percentile of 95 or above.
B denotes good work; a percentile grade of 85-94.
C denotes fair or average work; percentile grade of 75-84.
D denotes passing work; percentile grade of 65-74.
E denotes unsatisfactory work; percentile grade below 65.
F denotes failure.

In order to obtain marks that will represent something to the student and satisfy the registrar we translate the raw score into letters corresponding to the exhibit above. Accepting the results and advise of professional statisticians in the field of education, it seems equitable to place the letter grades approximately in accordance with the following scale: *about* 6 per cent—A's; *about* 24 per cent—B's; *about* 40 per cent—C's; *about* 24 per cent—D's; *about* 6 per cent—Fail.

UNIVERSITY OF TENNESSEE

DEPARTMENT OF BOTANY

Botany............................ Name................................ Section No.................

Examination............................... Date....................................

Do not turn to the following pages until told to do so. Fill the blanks above. WRITE PLAINLY.

General Instructions and Information.—This examination is divided into parts or tests. The total time allowed for taking the examination shall be limited to.. Give consideration to all items, that is, attempt to answer or fulfill the requirements of each test.

(Space reserved for scoring by Instructor)

Test	Score
1.	
2.	
3.	
4.	
5.	
6.	

Total

Grade

THE SPACE BELOW RESERVED FOR WRITING AND SIGNING PLEDGE.

ILLUSTRATION 7.

It is known that some investigators recommend 3 per cent A's, others 10 per cent, the other letters being assigned definite values also, but we have been satisfied with results obtained by using the scale tabulated above. Attention is called to the fact that certain difficulties may develop whenever translation of the score to a letter-rating is attempted. The likelihood of meeting with a troublesome situation is greatest if the class is a small one, regardless of the scale adopted for use. To a certain extent such difficulties as are met with are more apparent than real. Theoretically there is something wrong when the majority of a class make nearly the same score. Perhaps the examination was too easy, perhaps the teaching was poorly done, perhaps one or two individuals did most of the preparing for the examination, etc., etc. In any event the teacher will be called upon to exercise judgment in interpreting the score in terms of a percentile rating and when

the class is composed of 25 or fewer students it will be found increasingly difficult to adhere at all strictly to such a scale as has been suggested.

Taking the concrete case illustrated in Table 1. Here we find that 141 students took the examination. There were 80 items in the examination therefore the highest possible score was 80. The highest raw score achieved by any student was 66, the next 65, two made 63 and so on down to 12, the lowest score made. Now 6 per cent of 141 is 8.41, so the 8 making the highest scores are marked A, i. e. raw scores from 61 to 66 earn an A. Next, about 24 per cent of the papers scoring next highest should be given a mark of B, but 24 per cent of 141 is nearly 34, and counting down it is seen that 34 includes three of the group of 7 that made scores of 51-52. Consequently only 31, or about 22 per cent are included in the B-rating. At least 40 per cent should rate C but it seems logical that the dividing line between C and D should fall between scores 40 and 41, thus including nearly 62 of the scores or about 44 per cent of the total number. Again, about 23 per cent of the scores are rated D because of the natural break in the score frequency tabulation (Table 1). This leaves only a little over 6 per cent; some 8 scores at the bottom of the list that rate the mark of F. Under varying circumstances a larger number might be failed, but here as in the other categories the number of scores included will have to be varied somewhat from the normal at the teacher's discretion.

Summary.

1. Improvement in botany examination technique has not kept pace with the improvement in textbooks and general pedagogical methods.

2. The traditional essay-type of examination as frequently given has been shown to have short-comings: e. g., (a) non-objective, especially in scoring; (b) not reliable, because it fails to measure accurately and consistently; (c) only relatively restricted sampling of subject possible; (d) frequently fails to measure student's knowledge of the subject; (e) fatiguing for both student and teacher.

3. In our experience, examinations composed of a few of the newer type of objective tests have been in use for some time and we find that they fit satisfactorily our teaching needs and subject-matter as well.

4. In the body of this paper several sample pages from random examinations are presented for illustrative purposes. Directions

for building up one of the newer type examinations are given also, and comment is made on the procedure for scoring and marking.

ACKNOWLEDGMENTS.

The writer wishes to acknowledge the helpful assistance of Dr. L. R. Hesler, who read the manuscript and has collaborated in the development and use of objective examinations in the University of Tennessee, Department of Botany. Miss Willa Love Galyon has assisted by preparing some of the illustrations presented and in other ways. The writer is happy to acknowledge her help as well as that of several others who assisted in various ways.

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LIGHT SPEEDS FACTORY WORK.

Far less waste in human energy and health in thousands of factories throughout the country may result from a series of novel lighting experiments just completed by C. E. Ferree and Gertrude Rand of Bryn Mawr College. A paper emphasizing the high lights of the experiments was read before the joint session of the annual conventions of the National Committee for the Prevention of Blindness and the Illuminating Engineering Society in Chicago.

A number of factory workers were tested for the quickness with which they could see details in terms of black and white. It was found that whether the object is white against a black background, or vice versa, there is a rapid increase of speed as the amount of light is increased, up to 15 or 20 foot-candles. One foot candle means the light a man gets on his work when it is one foot from a standard candle.

The significance of the tests is that the application of three to four times the usual amount of light multiplies the speed of the work virtually by a corresponding amount. Furthermore, the prevailing opinion on factory lighting is that four to five foot-candles are adequate for general purposes. In other words, while there is no way of measuring a man's eye strain, the tests prove conclusively that eye strain may be lessened greatly by increasing the light to the point where the eye will work at its optimum speed.—*Science News-Letter.*

A RITUAL AND OTHER DEVICES FOR HIGH SCHOOL SCIENCE CLUBS.

By Louis A. Astell,

*West Chicago Community High School, West Chicago, Ill.**

From time to time the question of the relative scarcity of high school science clubs affiliated with the State Academy has presented itself to me. Recent communications from the chairman and the state secretary have served to indicate the possibilities of the ritual and other devices with reference to this particular problem. The matter of creating an appeal to those whose best interests such affiliation would serve—that is, to the high school science instructors and students—must begin with a demonstration of practical values.

Possibly the devices I am about to discuss are being used in other science clubs. In any event, it is not intended that they be considered either new or original. If, however, the applications of the ideas, as suggested, serve in any way toward a more numerous group of affiliated science clubs, I shall feel content. The specific devices which I shall consider are standardized club pins, standardized cards of membership credentials for individuals, and a standardized ritual to include illustrative material. These three devices, in some form, have been employed in the two clubs with which I have been identified. The results, it may be said, were sufficiently satisfactory to warrant their use again should nothing more appropriate be available.

The first club to which I have just alluded was organized in a more or less isolated community some six years ago. Certain incidents preceding its origin indicated the need of considerate action on the part of any one who attempted to present scientific conceptions to the students there. The idea of the ritual as it was developed, then, may be accounted for in terms of the rule of causation proclaimed by the ancient Leucippus, "Nothing happens without a cause, but everything with a cause and by necessity." My primary objective at that time was to illuminate a peaceful path between science and religion. It may also be noted, however, that through such a plan it is easy to establish something of the ethics of science and something of its humanism as well as its material benefits, thereby approximating to a more accurate degree the totality of the needs of those who think to travel by its light.

*Read at the High School Section meeting of the Illinois Academy of Science, April, 1927.

The objectives of citizenship and life interests as concrete examples are easily encompassed by the ritual. The significance of citizenship is being appreciated more and more by educators. Elementary science text books are being built around that essential of human welfare and progress. Such texts may serve well for the time allotted to work, but what of play? Not every boy has the opportunity of being a scout; not every girl has the privilege of being a member of a camp fire organization. Even if they could be, there is still no assurance that they would find in such activities exactly what each needed in this respect. Spencer points to this when he says that to educate rightly is not a simple and easy thing, but the hardest task which devolves upon adult life. Through the ritual and in the presence of the symbols of citizenship accompanied by appropriate interpretations of them, the student may become better acquainted with an adequate appreciation for the traditions and institutions of our democracy. He may also satisfy certain life interests and values for which he is as yet ineligible without indulging in objectionable secrecy. High school students of today have some idea of formal and informal initiations that enter into collegiate fraternities and other (adult) fraternal orders. Sociology indicates that a desire for such activities is more or less instinctive. Furthermore, the use of the ritual in science club work may, through the psychological principle of substitution, help to prevent any tendencies toward the establishment or growth of illegal high school organizations that exist by virtue of carefully planned and executed alibis. The conceptions of good citizenship and life-interests as correlated with the spirit of science have appreciable possibilities.

A standardized ritual worthy of use in clubs affiliated with the Academy would require some effort to prepare. Once completed, however, it should be of real value, particularly if supplemented by carefully edited illustrative material in the form of a series of opaque pictures for use in suitable projectors, films, slides, and the more convenient film-slides. In these three forms almost every possible demand for "picturization" could be met. In the second club with which I have been identified, opaque pictures were used and supplemented by films bearing on the life of Edison, whose name was selected to designate the organization. If care is taken in selecting names for the local organizations, much supplementary material in the form of films that will add a further note of interest to the work may be obtained. In many

instances such films may be had from industrial and other sources for express charges. Lists of these films with synopses and sources would be advantageous. The series of opaque pictures, the slides, and film-slides should—under specified conditions—be available for loan from the Academy to the affiliated clubs for use in the initiation ceremonies.

A standardized card for membership credentials for each individual should bear a statement of affiliation and also the signatures of the state officers as well as provisions for a counter signature. The ritual and the card together with the standardized pin, linking individuals and clubs alike would—it is believed—serve as a further incentive toward increasing the number of clubs. Certainly the dignity of these measures is at once apparent, and the pride necessary to the growth of any institution is apparent as a natural and unescapable consequence.

To reach the instructors, who must in the end sponsor the clubs, may be rather a difficult problem. Science teachers, as a rule, are busy with such a multitude of details that only those who have attempted the work of organizing and conducting simultaneously several courses in science can appreciate the view taken toward the added responsibilities. Yet science teachers, I think, are as quick to recognize values as any other group. If they could have the assurance that distinctive materials for the development of a science club were easily available, this fact would constitute a forceful argument for the furtherance of affiliations. In addition to the use of mailing lists and of space in the scientific magazines, a simple and direct method of approach would be to enlist the aid of those in charge of science teachers' training courses in the several schools throughout the state. A portion of one class hour devoted to the cause of extending the benefits of science beyond the class room is neither too great a thing to ask, nor yet too much to give.

Wiggam has said, "The things science has discovered are as nothing compared with the spirit and kind of life it has brought into the world. The spirit of science is worth vastly more than the discoveries of science." The standardized card of membership credentials, the standardized pin, and the ritual with edited illustrative material, all represent details among the many possible ways of contributing to the significance of that spirit so necessary as a guide in the discovery of our future.

I am glad of the opportunity of addressing this section of the Academy, because I feel that the Academy represents a means

whereby the spirit of science may find its way into the consciousness of the commonwealth it is now serving fully in other ways.

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MAN EATS LITTLE OF TOTAL.

Burning 8,900,000,000,000 tons of coal, 8,900 times as much as the world produces in a year, will release about as much energy as contained in the sunlight captured annually through the production of plant foods. Of this huge total, the human race uses less than two-tenths of a per cent., according to an estimate by Dr. John M. Arthur, of the Boyce Thompson Institute for Plant Research.

Every day each one of the 1,750,000,000 human beings on the earth consumes about 2,000 calories of food. Even meat comes indirectly from plants. The human race is therefore dependent on photosynthesis, the process by which the plant uses sunlight to form food. The total consumption of food during a year by man amounts to about 1,200,000,000,000,000 calories. All of the other animal life, vertebrate or invertebrate, large or microscopic, on the globe are estimated to consume about six times this amount.—*Science News-Letter.*

WHALES CHAMPION DIVERS.

Whales make the stoutest sub-marines look exceedingly tame when it comes to diving. According to R. W. Gray, a British naturalist, they reach depths of 700 to 800 fathoms, or from 4200 to 4800 feet, when they are attacked. They do not make a gradual, sloping descent, either, but stand on their noses and go right straight down. This behavior is known to whalers as "sounding."

In the old days, when whales were hunted with hand harpoons or with gun harpoons of a type that did not kill them quickly, the huge sea beasts frequently died at the limit of their dive, and getting them back to the surface was a long and arduous task. Sometimes in shallow water they crashed into the bottom and thus killed themselves.

Mr. Gray is of the opinion that the thickness of the whale's blubber, or protective layer of fat, may have something to do with its "sounding" ability. He notes that the Greenland whale, which has very thick blubber, can reach much greater depths than its relative, the narwhal.—*Science News-Letter.*

SIR ISAAC NEWTON AND THE INTERRUPTION OF HIS STUDY OF GRAVITY.

By Daniel W. Hering,

Professor Emeritus of Physics in New York University.

It has become the fashion to attack homely stories that are attached to the lives of great men. Some of us who have no claim to greatness feel keen regret when doubt or discredit is cast upon an agreeable legend but, in the case we are about to relate, this regret is mitigated by another story in friendly association with that which is threatened.

A remarkable story that was long unfinished is that of Newton's attempt to apply the so-called law of inverse squares to the motion of the moon in its orbit around the earth. This was almost the earliest stage in the development of his great theory of universal gravitation, and a gap of nearly twenty years intervened between his first effort, which was disappointing, and the announcement of his final success; and during this long interval the subject apparently lay dormant. This law, which is fundamental in the theory, is simplicity itself in principle, declaring merely that if the attraction between two bodies amounts to a certain force when the bodies are at one distance from each other, then, at twice that distance the force will not be twice as great, or one-half, but one-fourth as great; at three times the distance, not one-third but one-ninth as great; at four times the distance, one-sixteenth as great; and so on, varying in proportion to the square of the distance; smaller in that proportion as the distance is larger, or *vice versa*—that is what is meant by varying inversely.

The story properly begins with the familiar anecdote of the great philosopher in whom a whole train of reflections upon gravity and its mysterious character was set going by the fall of an apple. If gravity caused apples and stones and all sorts of things to fall to the earth, might not the same influence extend much farther into space than had been tried? Why not to the moon? For various reasons he thought the law of inverse squares was the true expression of proportion in which the force varied at different distances, and he proceeded to apply it to the moon. This satellite revolves around the earth in 27d. 8h. very nearly. Her distance from the center of the earth was known to be just about sixty times the radius of the earth, or the center of the moon is sixty times as far from the center of the earth as is a

body on the earth's surface, but how far was this? Astronomical observations tell us the distance not in miles but in terms of the size of the earth—how big was the earth? One degree of a great circle of the earth, a meridian, was taken by navigators to be sixty miles, and that was a generally accepted value and, say the histories, was the length of a degree which Newton used for his calculation. Then, the entire circumference of 360° was 21 600 miles and the radius was 3438 miles. It was known that at the surface of the earth a body fell 16.08 feet in a second; if it were sixty times as far from the center of the earth and the law of inverse squares held good, the force of gravity acting upon it would be only 1-3600 part as great and it would fall only 1-3600 part as far in a second, or something over 0.0044 feet. At a distance of sixty times the radius of the earth a body would fall just as far in a minute as, at a distance of one radius, it falls in a second; i. e. 16.08 feet. Was the moon doing so? According to the above figures the moon was describing a circle around the earth at a distance of sixty times 3 438 miles in 27d. 8h., and to follow its curved path it had to leave the straight or tangential path, all the time bending in toward the earth or, as we say, falling toward the earth, and it is no very difficult problem to compute the rate at which it is so falling—certainly not difficult for such a mathematician as Newton who, according to the stereotyped record, readily computed that it fell only a little more than 0.0038 feet in a second, or 13.9 feet in a minute—quite too little to meet the demands of gravity. Thus, Newton in 1665. The result was discouraging. He concluded, we are told, either that the law did not apply or that other influences upon the moon prevented it from conforming to the law, and so, as he himself wrote, he "laid aside at that time, any further thought of the matter." Now, if the moon were farther from the earth but performed its revolution in its orbit in the same time, it would be traveling faster and would fall toward the earth at a greater rate. According to the generally accepted history, it was some seven years after this that Newton learned, at a meeting of the Royal Society, that the French astronomer Picard had made a careful measurement of the length of a degree of the meridian near Paris in 1670, and found it to be nearly seventy ($69\frac{1}{2}$) miles instead of sixty miles. This was an impressive piece of news although, at the time when Newton made his computation (1665) he was aware of other determinations of the

length of a degree that he could have used if he had thought it worth his while; and that he did not immediately recalculate in 1673 (if that was when he learned of Picard's measurement), or that, according to Sir David Brewster's history, he should have resumed it with this corrected datum in 1683 with no more reason for doing so then than earlier, could only be ascribed to the eccentricities of genius. Sixty-nine and a half miles instead of sixty miles for a degree, in his original computation, would have given him just a little over 0.0044 of a foot for the fall of the moon in a second, and a very close agreement between the theory and the fact. Newton was busy with optics as well as pure mathematics, and although he did revise his figures for the moon's motion, his recalculation was not made known until 1684. The dates connected with this work are not as well established as could be desired, but apparently sixteen years or more intervened between his earlier and his later computation. *The Principia* was completed late in 1686 or early in 1687, and then it was found that he had used his later result in the development of the great work; but it is a mistake to conclude that only at that late date did he make the correction *or that he relied upon that correction for the proof of his theory of gravity.* For more than two centuries has this unfortunate error and the correcting of it so many years afterward, been dilated upon. The publication of the *Principia* in 1687 marked an epoch in science. This great exposition of universal gravitation stood supreme for two centuries, and under its shelter nestled snugly the pleasant little story of its origin in the fall of an apple (at least from the time of Voltaire, through whom this anecdote came to public notice); and also of the interruption and delay owing to a mistake as to the size of the earth. The former of these is a pretty story and is better substantiated than many others of the class in which it belongs. The second point, the cause of the delay, the explanation of the hiatus in Newton's work and his resumption and triumphant completion of it, calls for a readjustment of our view which does not interfere with the other but gives more prominence to something else that strongly influenced Newton. It is remarkable on what a slight foundation rests the idea that he used the value of sixty miles for a degree. There is no really good evidence that he did so; the idea has no better backing than the "apple" story if as good. Newton does not say what value he took; the statements regarding this come altogether

from one or two contemporaries and from the inferences of his biographers. There is one statement of Newton to the effect that the result of his first computation agreed with the theory pretty well, but not well enough—he was not wholly satisfied and he doesn't say just why. That the failure of his calculation to agree with the facts was the reason why his theory of gravitation lay fallow so long is open to more than a reasonable doubt. There was another contingency that demanded consideration ahead of the simple law of inverse squares and perhaps outweighed the attempt to extend this beyond the earth, and until this was settled he could not be sure that the law was confirmed even if his calculations upon the moon checked up correctly. The law might be true and yet it could not be applied to such a case as this unless it were proper to regard the attraction of the earth for the moon to be the same as if the mass of the earth were concentrated in one point, the center. This was still a question; was it certain that, under this law, the attraction upon a body by a sphere like the earth was the same as if all the sphere were concentrated at its center? Nobody knew that for a fact. Newton guessed it was so, and he was always a good guesser—what he guessed was about as good as what most people knew—but he did not rely upon guesswork in presenting his conclusions to other scholars. His contemporaries were more than ready to combat his views and he trusted to nothing short of real proofs; and no matter when he corrected his computation by using a corrected size of the earth, he could not feel assured of the theory of gravitation until he found a satisfactory demonstration of this assumption regarding a sphere. Without this his general theory of gravity would be rickety if it did not actually go to pieces. When he consented in 1684 to prepare the *Principia* for publication *it was all there*—all about the attraction of a sphere, and a good deal more about attraction besides that—although it is not known just when he achieved this particular proof. In modern physics this theorem of the attraction of a sphere is a part of a comprehensive set of principles designated the "Theory of Potential," and it is readily proved by means of the calculus; but the calculus, a powerful instrument of mathematical analysis, was itself invented by Newton and was at that time scarcely known, even to able mathematicians. In the *Principia* Newton proves these critical theorems by ordinary geometrical demonstrations.

The bicentenary of the publication of the *Principia* was celebrated at Trinity College, Cambridge, Newton's academic home, on April 19, 1888. Many eminent scholars were in attendance, the principal address being delivered by the distinguished mathematician, Dr. James Whitbread Lee Glaisher. This speaker dwelt upon the points to which we have here called attention, and explained how they had been brought to light by the celebrated astronomer, John Couch Adams, as a result of his examination of the "Portsmouth Collection" of manuscripts and documents. Dr. Glaisher supported this interpretation of Newton's action. In *The University Chronicle* of the University of California, for 1922, Professor Florian Cajori, to whom we owe much valuable history of mathematics and physics, presents a good summary of the "Adams-Glaisher hypothesis," as he terms it, carefully weighing the pros and cons, with the conclusion that this hypothesis is by far the most probable. If it is correct it indicates that Newton knew very well what he was about in delaying the announcement of his work, and had no intention to rush precipitately into print with the solution of a problem that did not fully confirm his theory even if it did support it. What is more to be wondered at is that the better explanation should have been obscured by a minor one and, like the Seven Sleepers, should have lain undisturbed for two hundred years in its Cave of Ephesus.

CONTESTS IN THE SCIENCE CLASS.

By G. W. Warner, Crane Junior College, Chicago

Everyone likes a game or a contest. Science teachers should make use of this instinct in conducting reviews. A student who will not prepare a lesson assignment will often work overtime to win the game. Usually such a student does not care much what the teacher thinks of him but he fears to be ranked as a dullard among his classmates. The same stimulus is just as effective with the bright student. He works to prove his leadership.

One interesting type of review is fashioned on the old spelling school. Two of the best students are appointed captains who choose sides. Each leader then uses his ingenuity to prepare each member of his team for the contest. This brings effective study. On the day appointed the teams line up on opposite sides of the room and questions are asked by the teacher, first to one team then to the other, the students taking the questions in order. If a student misses he is down and the question passes to his opponent. If there are several sections, the winning teams of one section may want to challenge the winners of another section, or pick the best ten students from the section to challenge another section. This intersection contest makes a good program for the science club. If it is desired to penalize the losers they may furnish the eats.

WHY USE TEXTBOOKS IN TEACHING ELEMENTARY CHEMISTRY?

W. G. Bowers,

Colorado State Teachers College, Greeley, Colo.

The reason for proposing such a question as, why use a textbook in teaching elementary chemistry, at this time grows out of several circumstances to be considered. The main thing is the custom on the part of many college professors of teaching elementary chemistry to Freshmen by the lecture method. This custom is being adopted now by some high school teachers, and it is creating a serious problem in secondary education. Another thing which is responsible for the question, in a large degree, is a desire on the part of some college teachers, and not a few high school teachers, to follow their own outline of subject matter, which is slightly different from that in any known textbook. Another thing which turns some teachers away from an adopted text, is the popular interest in library reading. Some teachers have concluded that students generally dislike to get lessons, but that they like to get books from the library and read about interesting things. Another thing that brings up the problem is the growing tendency toward laboratory work. Many teachers are inferring, since laboratory methods are proving so efficient, that there is no place for a textbook even in elementary chemistry. Then last but not least, some young teachers just out of the training schools in which they have been taught to construct lessons plans, are laboring under the impression that they cannot have a plan and a textbook both at the same time.

The writer of this article is not an author of a textbook in elementary chemistry though it might be suspected that he was from the trend of the argument that follows, but he knows of several texts, which, if properly followed, will excel anything so far suggested as a substitute in elementary chemistry. We might emphasize the term Elementary Chemistry in this connection for the reason that there are many subjects in college and high school curricula of which the above assertion might not truthfully be made. In fact, nearly all courses in chemistry above the elementary course might very well lend themselves to other methods, depending on circumstances, but the more elementary and the more fundamental the course in chemistry, the more necessary it is to follow a plan which is the result of years of labor on the part of experts.

Textbook vs. Lecture Method

One of the first arguments for the lecture method is that many more students can be handled in one class. It is true, if dictating an outline or giving a collection of facts is all that there is to teaching the fundamentals of chemistry, that as many students can be handled in one class as the Teacher's voice is able to reach. If even explanations by a rare genius at that sort of thing brought best results, hundreds of students might be handled in one class. There are several objections to large numbers in a class, however, such as teacher's magnetism being limited, student's mental response being less for the more students present, etc. It is useless to enumerate more along general lines, but for fundamentals in chemistry there is demand for special consideration along several lines. The most important thing to consider is that we are not cramming the student with information. We are developing his power to use the scientific method. Our greatest problem is to get the student to thinking scientifically. The only way we can obtain that end is to have him enter into discussions or keep him thinking on the topic preparing himself to enter into the discussion at any instant, or have him organizing material so that later he can solve a problem or make an explanation satisfactory to himself. This cannot be accomplished where there are too many in a class.

If it may be conceded that the large number in one class is not an advantage, the next argument that might be made, is that for the same sized class the lecture plan concentrates the teacher's part of the work so that the students have more time for discussion. If this is under the assumption that the student has done no preparing outside of class for his part of the discussion, his part will be nil or worse than nothing. If the instructor spends part time giving facts, and part time drawing students out causing them to think for themselves concerning the facts and considers thought the profitable thing, then he must consider that he has been uneconomical with the part of the time which he spent giving the facts. Furthermore, this would not be the lecture plan, it would be a mixture. It would seem evident that an hour spent discussing topics on which the students have spent an hour reading and studying before hand would be more profitable than an hour divided between lecturing and discussing. Of course, it might be unfair to assume that the lecture gives no opportunity for preparation previous to discussions. The instructor can and does have it understood that topics on which

notes are taken one day will be discussed the next day. This furnishes the student an opportunity to do some original thinking before undertaking to express himself, but it does not remedy the waste of time on the part of the instructor. He yet has to devote the same fraction of the hour to the giving of facts for the next discussion. Then again, the division of the hour results in a smaller amount of time required on the part of the student for his previous preparation for the discussions. It simply means that all the student has to study for the next day's discussion is what he could write down in about one-half hour.

Another argument for the lecture plan is that students hearing a thing from a great personality in whom they have faith, will remember more and remember longer what they hear than if they had read the same from a book. This has to be conceded in many cases especially in the study of civics, history, and sociology. It does not hold so good, however, in a definite and deep-seated science like chemistry. One reason for this fact, as generally applied, is that reading is more common than listening. Perhaps if the average student listened to lectures as much as he reads, he would get as little in proportion from the lectures. Perhaps if the lecture gave hard scientific facts in a monotone (and most of the scientific facts will not admit of demonstrative expression), for several hours at a stretch, the student would become as inattentive as he does to his reading, and would remember as little of it. And perhaps if students had to obtain nine-tenths of their education by listening to lectures, they would appreciate reading for the other tenth, then they would get that tenth in a better grounded way.

As has been brought out often in recent articles on this subject, getting information well-grounded is not the chief end in studying chemistry. The chief end is developing the scientific attitude or scientific method of approaching problems, or cultivating scientific thinking. In following a lecture course, the student has to give his whole mind to the writing of notes, so that he has no time to think about anything but getting the material in form so that he can interpret it later. Then later when he undertakes to interpret it he has the same proposition that he has with the textbook as far as cultivating his own power to think is concerned. When it comes to the matter of the instructor aiding the student in developing the power to think as he explains problems and relates facts, he can spend only half of the time at this sort of work if he has spent the other half

making the problems and giving the facts. So from this phase of the question we are driven back to the same proposition, that is, the uneconomical use of time on the part of the instructor, and the lack of sufficient effort on the part of the student.

Another argument against textbooks, that their use deprives the teacher of his opportunity for original thought and his originality in presenting things, is not well founded. It may deprive him of some opportunity for original thought, but it does not necessarily deprive him of exercising originality in presenting things. On every hand now, college professors are lamenting the fact that too many high school teachers have started their students in different ways, and strenuous efforts are being made to standardize the foundational courses. So the time will be heartily welcomed when the teachers of elementary chemistry will cease to exercise original thought as far as content and arrangement of material in courses are concerned. There will always remain to the teacher the opportunity of exercising originality in the presentation of things. As far as explanations are concerned, as far as throwing extra light on relationships is concerned, as far as the manner of attack is concerned, and as far as all ways and means of developing scientific method in students are concerned, teachers will continue to have their own way, and plenty of room for originality.

The interest in popular library books is a fine thing. Slosson's popular books on chemistry are excellent, but it is not necessary that they serve to turn students' and teachers' attention from texts that are more profound and difficult to study. It is true there are a few students who will say, "If we could get texts as readable as Slosson's 'Creative Chemistry' we would not mind lessons in chemistry." It is hard to explain to such students that elementary texts including the fundamental principles of chemistry cannot be made as readable as that. The more substantial students, however, are not hard to convince that a textbook should be constructed on different principles and that such books as Slosson's are good only for side reading. Some teachers seem to get the idea that in order to have a popular and modern course in anything, they must not assign pages or topics in a textbook, but that they must have only library references read. They forget that this sort of thing is good only for subjects calling for latest news which cannot be incorporated in texts for lack of time. It has been tried in chemistry and has been proven to be a dismal failure. Mr. Foster, who tells in

Chemical Education, Volume II, No. 11, how his students are not required to own a text, explains that the students have access to state owned texts. It seems as tho the only difference is that the state instead of the students owns the texts. Since this article is intended merely to be an argument for the use of texts, it would seem improper to devote much time to proving that it is better for the students to own the texts individually than to own them thru the state. It would appear that they could make more and better use of the text if they could take it with them wherever they go and mark it up to suit themselves.

Another tendency to get away from texts is due to the tendency to do more laboratory work. The importance of laboratory work should not be minimized. The idea that laboratory work should be in greater proportions as the courses diverge toward the practical fields, should never be interpreted to mean that laboratory work should entirely supplant textbook work in the beginning courses.*

Modern professionalization should not be condemned, but rather adjusted to suit the different problems as they present themselves. If a young teacher has learned in his training school the importance of lesson plans and how to make lesson plans, he should not of necessity discard textbooks from courses like elementary chemistry, but should rather let this knowledge serve as an aid in assigning lessons in a text book. If he makes proper use of this knowledge, he will probably not assign lessons from page to page in the text. He may assign by topics. He may change order of topics. He may not necessarily do either. The main thing that he will do is to call attention to topics that are more important than others and to phases of the topics that are more important than other phases. He will call attention to certain sequences. He will ask the student to study certain relationships, and to make certain classifications and organizations, and to make certain contrasts and comparisons. He will explain the author's plans. He may omit some of the author's problems and supplement others. But all that he does will rarely upset or even disregard the plan as given in the text. Many of the texts now in use have lesson plans equally as good as the young teacher just out of college can make. All the teacher needs to do is to adjust himself and his plans so as to aid in getting the student to see the larger plan.

*See School Science and Mathematics, Vol. 24, No. 8, page 815, for what most schools are doing along this line.

Some teachers would do away with the best texts in existence merely because they deal with some fundamental principles which are not applicable in the every-day life of the youngster going out from the high school. They argue that since not more than twenty percent of the high school chemistry students expect to pursue chemistry in college, a shallow practical course should be given. We want to say here the same things which we said in our discussion of the character of laboratory work,* excepting we should say more for fundamental principles to be given in a textbook than in a laboratory course, for the reason that many of the most important fundamental principles are too intricate for beginners in the laboratory, but they must be dealt with somewhere and the textbook is the better place.

It will readily be conceded that the student of today should not be required to relive the experiences of all the chemists in their laboratory work in which they brought out the great fundamental truths underlying the study of modern chemistry. It ought to be as readily conceded that he should not be required to relive the experiences of the chemical educators who have brought together a selection of those fundamental truths and expressed them in teachable forms, and organized the expressions in logical ways and built up schemes of drawing out scientific thought as applied to the study of chemistry, and called them textbooks in chemistry. The teacher who advocates no use of textbooks in answering questions in an originally constructed lesson plan in which he has not wasted the time dictating the answers verbatum, is practically requiring the students to search vast columes oı literature for the answers to such questions. In many cases, in order to obtain as full answers as a good text book gives, the student would have to have a reading knowledge of French and German and investigate the literature written in these languages. This is a splendid type of work for advanced students. For elementary students, a little of it along simple lines, dealing with familiar things, is good just as some simple laboratory work is good; but to go to extremes such as would be be necessary if texts were discarded entirely would be as great folly as to require a student to determine the form of an atom of sodium by laboratory method before he had had one year of chemistry.

It may be assumed that the project method is better for culti-

*Op. Cit. 25, No. 7, 711.

vating scientific thinking than is plain reading. That would depend somewhat on the character of the project and the form of the reading. But it must be assumed that in order to get a start in any line of thinking one must have some ground work. One must know some fundamental principles, and be able to remember some things that occur along the line. It must be assumed also that a scientific thought could never come without being supported by something fundamental and without being preceded by something remembered.

The textbook is for the purpose of putting forth the fundamental principle in such a way that the student with the aid of the instructor can get a working knowledge of that principle, and for the purpose of giving information in such a way that the student by the aid of the instructor can make use of that information in solving scientific problems and arriving at more information.

We who advocate developing in the student the ability to think rather than to remember, must not lose sight of the fact that we remember in order to think and that we think in order to remember, and that even in these days of encyclopedic information, we get information so that we can solve problems and that we solve problems so that we can get information. But the teacher who advocates the students reliving the life of the one who has furnished us with the text-book, takes us through a cycle from information to problem and back to the same old information. Progress requires that we take the old information as it is given, and spend our lives building something new upon it.

It is not necessary to infer from the foregoing arguments that the student be expected to remember all that he reads in his textbook. It is a fact that some teachers condemn textbooks because students can not remember all that is in them. It is this idea that causes them to recommend the lecture method or some other method by which they get less of workable information in the time spent. Such teachers forget to exercise their own ability to think scientifically and to see that a great deal of the material in the text is put there for the purpose of helping the student to get an understanding of the fundamental principle and thus helping himself to remember the principle. It is not necessary to infer from the foregoing arguments that the beginner should do all of his studying from one adopted text. He should do some laboratory work; from one-fourth to one-half of his time should be devoted to this phase. He should do a little library reference

work, and some notes should be taken on material given from the instructor. It would be fine if, as in the California University High School, he could have access to a variety of texts. But the time must not be allowed to come when textbooks are discarded entirely.

Any type of structure calls for a foundation whether or not the same designer and builder takes the structure from ground work to completion. Even under these circumstances certain standards must be followed. Under circumstances, as in the building of a chemist, in which the high school work is given in one place under one administration and with one type of teacher, and the college work in another place under another administration and with a different type of teacher; a foundation with certain fixed standards is absolutely indispensible.

With this in mind there is no wonder that the leading chemists and chemical educators from all parts of the country are getting together and discussing ways and means of standardizing the elementary courses in chemistry. These leaders realize that a variety of texts differing in outline and content are responsible for a great drawback. It is readily seen that the library reference plan, the lecture-from-personal-notes plan, the individual teacher's lesson plan, and any plan offered as a substitute for the standardized text with its accompanying laboratory manual, would be even worse than the variety of texts. The time will come when we will get away from the variety of texts, but not in the direction of any of the above named substitutes, rather in the direction of standardized texts, written according to a uniform plan. They may be written by different authors, but they will follow the uniform plan.

WIND MAKES ALKALI FLATS.

Why are western alkali lands so frequently found near lakes, and why are such lands always found on the lee shores? This is a riddle as old as western farming, for which an answer is now proposed by Dr. W. L. Powers of the Oregon State Experiment Station.

It was the drying up of a shallow lake on the Oregon-California line that gave Dr. Powers his clue. A series of dry years culminated in the total disappearance of water from its bed, which is about 13 miles wide and 20 miles long. As the water disappeared, alkali salts were evaporated out. Then a windstorm came from the southwest and blew this chemically loaded dust far out on the shore.

Dr. Powers is now of the opinion that this climatic behavior, often repeated, is responsible for these wide alkali flats, where nothing but greasewood will grow.—*Science News-Letter.*

OBJECTIVE MEASUREMENTS OF THE RESULTS OF SOLID GEOMETRY TESTING.

W. T. WAIT,
Colorado State Teachers College, Greeley, Colo.

Probably no teacher of solid geometry has found the testing part of class work an easy matter. It is equally probable that no teacher of solid geometry finds it easy to diagnose correctly the difficulties of the pupils in his or her classes. There are several reasons for this, among the more prominent of which, may be mentioned the lack of objectivity of the aims of the course and the obstacles in the way of securing usable items for test material in small enough units to permit a fair sampling and also of determining the difficulty of these units. By way of contrast, spelling is an example of a subject that does not offer these difficulties. The aims of a spelling course for any particular grade have been fairly well defined in objective terms. Diagnostic testing as well as testing for final achievement is comparatively easy due to the small units of material and the known difficulty of each unit.

The ultimate aims of solid geometry teaching are not well defined. The course is usually elective and those who elect it are, in large proportion, doing it as a part of a college preparatory course. For such a group the mastery of the subject matter is probably one of the most important aims. Training in ability to reason logically is an important aim of the course according to many teachers of the subject although a drill in formal demonstration of theorems or testing upon such drill does not appear to be even as justifiable a procedure as in plane geometry. Training in the manipulation of concepts of three dimensional space is another aim recognized as legitimate by many teachers. Recently the vocabulary of mathematics in all its branches common to the elementary and secondary schools has been shown to be of importance to the average individual in a non-vocational way.

In considering the question of material for diagnostic or achievement testing in solid geometry, the teacher is immediately confronted with the difficulty of the size and the desirability of the units for the tests and of determining their individual and collective difficulty. In the traditional type of examination, the pupil was called upon to reproduce the formal proof of two or three theorems, solve a problem or two and give a number of verbalized definitions, the meaning of which he might or might

not know. If the pupil had memorized his definitions and the particular proofs that were called for he was pretty sure to do well on an examination which stressed these items. If he was skillful in figuring areas and volumes he would do well on the tests which stressed computation problems. In either case the sampling was limited because of the comparatively large units in the examination. If the teacher was an exponent of the new-type examination many of these obstacles were avoided but there still remained the problem of determining how difficult the individual items of the test might be as well as the difficulty of the test as a whole. Moreover it was a difficult matter to secure enough items for the objective test to make it reliable and in any case the classes were usually too small to secure any adequate notion of the difficulty of the items or of the test as a whole. It lost, therefore, much of its diagnostic value.

In the Roosevelt High School of Seattle, Washington, Mr. M. E. Morgan, at that time a teacher of mathematics and now Vice Principal of that school, had been using a form of the new-type examination for two years in his classes of solid geometry. These tests were of the true-false type and were designed to test pupils' ability not so much in the formal demonstrations of the theorems as in their ability to deal with concepts of three dimensional space, their ability to use the concepts expressed by definitions, theorems, etc., and in their ability to solve problems of varying degree of complexity.

With these tests as a basis, a seminar class in educational measurements in the University of Washington, of which the writer was a member, undertook the construction of a standardized diagnostic and achievement test under the direction of Dr. August Dvorak, Professor of Education.

The original tests contained about five hundred items and covered the entire range of solid geometry matter as usually taught in a one semester secondary school course. Eight of the most commonly used texts in solid geometry were then analysed to determine what items were common enough to all of the texts to be included in a test suitable *to accompany any text.* It was found that there was no great agreement as to *the form* in which an item might appear in the eight texts examined. For example, an item might appear in one text in the form of a theorem, in another as a corollary, in another as a definition and in a fourth as a problem or exercise. All items common to all the texts *regardless* of the form in which they appeared were con-

sidered as legitimate material for the proposed test and the list of items so obtained was then compared with the items of Mr. Morgan's tests. All test items not found on the list compiled from the analysis of the text books were dropped and where items from the compiled list were not matched by adequate items in the tests, items were prepared. It is evident therefore that the test represents a serious attempt to include all of the concepts commonly taught in a semester course in solid geometry. It is worthy of comment that many of the concepts that were given most stress in the eight texts are represented in the test by several separate items, often quite different in point of view or in statement.

The items were then carefully edited to reduce ambiguities and divided into nine parts of approximately the same length. Each of the divisions of the test was of convenient length to be given in a single class period, thus providing for frequent tests which would increase their usefullness as means of diagnosis. The items were arranged in sequence so as to make the order of the material in the test correspond as far as possible to the most general practice in the texts. Each of the nine tests covers a subdivision of test material grouped around the presentation of a particular part of the subject matter as indicated by the names of the tests which follow: Test I and Test II, Lines and Planes; Test III, Dihedral and Polyhedral Angles; Test IV, Prisms and Parellelopipeds.—Volume; Test V, Pyramids; Test VI, Cylinders and Cones; Test VII, Spheres; Test VIII, Spherical Polygons and Spherical Areas; Test IX, Spherical Volumes.

All of the Seattle High Schools and several of the other larger high schools of the State of Washington, about twenty in all co-operated in a preliminary try-out of the test in the spring of 1926. Owing to the advanced season of the school year it was found impossible for any school to give all of the tests immediately after the presentation of the corresponding subdivision of the material in class. The number of tests given in a school varied from two to five with three as a median number given. The tests used by the several schools were so distributed that there resulted several hundred responses for each item. The reactions of a representative group of teachers were also obtained for the tests as a whole in the form of valuable criticisms and suggestions for further editing and improvement.

A tabulation was then made of all the errors of all the items of the whole series of the tests and the difficulty of each item was

thus determined. The seminar class which had worked with the test to this point was composed of graduate students of education, many of whom had previously had experience as teachers of solid geometry. At this point, however, the class disbanded and the remainder of the work has been done by the writer under the supervision of Dr. Dvorak.

The tests were given another careful editing in the light of the criticisms of the first try-out and the items in each test were arranged in the order of increasing difficulty except where several items referring to the same figure were arranged consecutively. It was felt, however, that since the editing had been quite extensive and that a number of the more ambigious items had been eliminated and that since the items were now in approximate order of difficulty that the scores on the tests might be considerably changed. Moreover in all but the last two of the nine tests, the try-out use of the test had not followed immediately the completion of the appropriate parts of the subject matter and it was recognized that norms based on the evidence of the preliminary try-out would be subject to change under the changed conditions of giving and should be considered only as tentative.

Another cooperative try-out was therefore arranged on a larger scale, involving more than four hundred and fifty pupils in the high schools of the State of Washington, with each pupil taking each of the nine tests after the appropriate subject matter had been completed in class.

The tests in their present form have from forty-eight to sixty items and are designed to be given approximately every two weeks as each part of the course is finished. There are four hundred and thirty items in the complete series. Only a few figures have been used and after the first two tests very few references have been made to the formal proof of theorems as it is the authors' idea that more emphasis may be legitimately given to such proofs in the first part of the course than in the last part when more of the emphasis is placed on other methods of teaching by most teachers of solid geometry today. The major emphasis has been placed upon the pupil's ability to use the facts given in the definitions, theorems, corollaries, exercises, etc. Many practical problems are included but none that require any considerable degree of computation with pencil and paper since it is designed as a test of ability in geometry rather than skill in arithmetic.

A few sample items, both true and false, are reproduced

here to give an idea of their nature:

Test I, No. 37. The intersection of three planes is always a point.

Test I, No. 46. Any three points determine a plane.

Test II, No. 39. If two angles not in the same plane have their sides respectively parallel, they must be equal or supplementary.

Test IV, No. 19. If two eggs have the same shape and one of them is twice as long as the other, the longer will have four times as much surface as the shorter.

Test V, No. 29. The volume of a regular tetrahedron equals 1-3 the altitude times a lateral face.

Test VI, No. 39. If two similar cylinders of revolution have radii of four and five units respectively, the larger has a volume more than twice as great as the smaller.

Test VII, No. 36. A Spherical angle is an angle formed by any two intersecting circles on the surface of the sphere.

Test VIII, No. 50. If "A" is the angle of a lune, its area is pi $R^2A/90$

Test IX, No. 12. A sphere whose area is 4pi must have a diameter equal to 1.

While it has not been possible to obtain individual total scores on all nine of the tests, the total scores of those pupils who took three or more of the tests in 1926 indicate that the tests distinguish consistantly among the pupils of varying degree of ability in solid geometry. Besides this, there was found a correlation coefficient of .735 by the Spearman rank-difference method, between total pupils' scores on the tests taken and final grades as given by the teachers. These total scores were used very little if at all by teachers in giving grades as the tests in 1926 were given on consecutive days near the end of the term. Such a correlation may therefore be considered as remarkably high under these conditions and points to very satisfactory results.

A final test covering items from all of the test is being prepared and will be given to more than four hundred and fifty pupils who are now taking the regular series. This will bring the total number of items in the series to over five hundred and from present indications will give a high coefficient of reliability.

It is the idea of the authors that the test scores will be cumulative and need not be converted into letter or numerical equiva-

lents until such time as reports are to be made according to the local administration. Such a conversion or distribution will be a simple matter at any time as norms and suggestive equivalents will be included with the keys and directions.

The time required for each test varied somewhat in the preliminary test and tended to be proportional to length of the period available to the pupils but in no case is there evidence that pupils needed more than a forty-five minute period. From the results obtained so far on tests I and II in the present try-out, the average time would seem to be between twenty and twenty-five minutes. The directions state that the pupils are to have as much time as they need within the limits of the period available. There is no evidence that those who take a longer time than average secure higher scores on the tests.

One of the most valuable features of the tests is their diagnostic function. Since the tests include practically every concept taught in the ordinary semester course of solid geometry, it is possible by their use to diagnose each pupil's difficulty *as each part of the work is covered.* This makes remedial instruction possible at the time it is *most needed and most easily given.*

It is the expectation of the authors that when enough pupil's scores have been obtained to secure a sufficient reliability to make up from the items of this series of tests, a Solid Geometry Scale in duplicate or triplicate form. These scale forms will be of suitable length to make it possible to measure accurately the progress of a class in a semester's course in solid geometry, to measure with reasonable accuracy the comparative results of two or more methods of teaching this subject and to be of use in any other research work in solid geometry teaching.

Arrangements have been made with the Public School Publishing Company, Bloomington, Ill., for the publication of this series of tests as soon as the present cooperative try-out is complete and they have been reedited in the light of the experience and criticisms resulting from their present use.

The tests will be titled the "Seattle Solid Geometry Tests" and will appear under the joint authorship of M. E. Morgan, W. T. Wait and August Dvorak. The teachers of solid geometry who have, and are, using the series of tests have not only greatly assisted with their suggestions and criticisms but have lent considerable encouragement to the work by the enthusiasm with which they have welcomed the use of the tests.

A SURVEY OF PHYSICS.

By Wm. S. Franklin,

Massachusetts Institute of Technology, Cambridge.

An understanding of the profound changes which modern research has brought about in the fundamental ideas and theories of physics can best be reached by a consideration of the four great methods in physics, namely, the method of mechanics, the method of thermodynamics, the method of atomics and the method of statistics.

The characterization of physics in terms of methods is more significant than the older subdivision of physics into branches according to subject matter. Thus mechanics, hydrostatics, hydraulics, heat, optics, acoustics, and electricity and magnetism are the old branches of physics and the boundaries between these branches are rapidly disappearing with the advancement of physics, in fact chemistry can no longer be considered as a distinct branch of physical science. The branches of physics grow less and less distinct as physical science develops, but the methods as above enumerated become more and more clearly recognized as distinct methods. The recent great changes in physics consist in very large part of the increasing recognition of essential restrictions and limitations of the various methods of physics; mechanics is not, for example, a universally applicable type of natural philosophy, and to understand the restrictions and limitations of the method of mechanics is a long step toward the understanding of modern physics. Another aspect of modern physics is that many of our fundamental ideas have been altered, some being made sharper and narrower than before, others being widened. The purpose of this brief article is to exhibit some of the modern advances in physics in terms of the restrictions they impose on methods and in terms of changes in our fundamental ideas, changes which are of importance mainly because they restrict our methods. In a brief discussion of this subject it is necessary to assume that the reader has considerable knowledge of classical physics and that he knows something of the principle of relativity and a little of the quantum hypothesis.

The first really effective method to be employed in physics was the method of mechanics. This method was founded by Galileo and Newton, and, as the method was developed and more and more successfully applied, it came more and more to dominate the philosophy of physics, until, about the middle of the

nineteenth century, the "mechanical conception," as Planck briefly calls it, was generally believed to be an adequate basis for the analysis of all the phenomena of nature; the "mechanical conception" is the view that all phenomena can be reduced to movements of particles or elements of mass, and the "mechanical conception" aimed to explain everything in terms of motion.

The discovery of the principle of the conservation of energy (which was at first thought to be a purely mechanical principle) tended to strengthen the "mechanical conception" and the development of the kinetic theory of gases was looked upon as a sample of the unlimited conquests which the "mechanical conception" was destined to make. The latter part of the nineteenth century was the Golden Age of the "mechanical conception."

The method of mechanics is still retained in physics and it is applicable to all large-scale phenomena where irreversible processes do not exist or where irreversible processes are negligible, and the method of mechanics thus widely used can be defined as including everything that conforms to and falls under the principle of least action; but the method of mechanics so defined, which Planck calls the method of dynamics, is by no means the same thing as the "mechanical conception" because in many cases it is independent of any knowledge of or any postulate concerning things or substances or particles which move, and because no one now imagines the method to be universally applicable.

It is apparently absurd to speak of a method as a mechanical method or as dynamics (after Planck) when there is no thought of motion of concrete things but at best only motion of energy (as in the case of light); but the above-mentioned method of mechanics, in its mathematical aspects, in the kind of correlation which it accomplishes and in the kinds of measurements involved in its experimental researches, is the same old method of mechanics.

The reader will be left, as it were, in a mental vacuum by the above reference to the principle of least action as the thing which characterizes the method of mechanics, and it needs to be pointed out that the most advanced students of mathematical physics are but little better off than the reader in this respect, for no one as yet has any intuitive appreciation of the principle of least action nor any conceptual insight into its meaning. The mathematical physicist only knows how to formulate the principle mathematically and how to derive its consequences. The prin-

ciple of least action applies to all large-scale mechanical phenomena, to all large-scale electromagnetic phenomena (including light) and to all large-scale thermal and chemical phenomena; but it fails in all these fields when there is any irreversible action, or when it is applied to "microscopic systems" (to atoms and molecules). Because of this failure of the principle it is better to say that it is useful in correlating large-scale (macroscopic) mechanical, electromagnetic, thermal and chemical effects when the accompanying irreversible action is negligible. All these effects are highly idealized when irreversible action is ignored because every phenomena in nature is accompanied by some irreversible action, and, of course, irreversible action is very much in evidence in many thermal and chemical phenomena.

Another method in physics, the method of thermodynamics, overlaps the method of mechanics, but goes beyond the method of mechanics inasmuch as it recognizes the existence of irreversible or sweeping processes in nature; but the method of thermodynamics has nothing to do with irreversible or sweeping processes themselves, but only with their results, and indeed with only one result, namely, the increase of entropy. This characterization of the method of thermodynamics can be made much more intelligible as follows: The chemist is never (or almost never) concerned with chemical actions themselves but only with their results; the steam engineer is not concerned with the details of behavior of the fire under a boiler; imagine an engineer looking into the fire with a million microscopes and recording the infinitely complex details of the fire! It is not done! The important thing about a boiler plant is the amount of steam that can be produced by the burning of a pound of coal, and this depends on (1) the temperature of the feed water, (2) the condition of the air and the coal which are to combine in the furnace, (3) the pressure and temperature of the steam which is to be produced, and (4) the condition of the flue gases as they enter the chimney. That is to say, it is necessary to consider only the states of things *before* and *after* the combustion takes place. The only measurements that need to be taken (the only measurements that can in general be taken) are measurements of substances in quiescent states. The thermodynamic method may therefore be called, in mild derision, the "before-and-after method" because this is as near as the method ever gets to a consideration of an irreversible or sweeping process; and the increase of entropy due to an irreversible or sweeping process

can be expressed in more intelligible terms by stating the amount of conceivably available work that is lost by the sweeping process.

Another method in physics is the atomic method, or *atomics* as it is often called. It is certainly true that atoms themselves are now the objects of observation and measurement in the laboratory, but only when the fourth method, the statistical method, as described below, is used. The great theoretical structure which is called the atomic theory, especially that branch of it which is called statistical mechanics (Gibbs) of which the kinetic theory of gases is a special case, is based even now on postulates; for no one could maintain that our real knowledge of atoms is of the kind that could be used as a foundation for any elaborate mathematical structure. The atomic method is the building up of elaborate pictures or conceptions of physical conditions and things, and its chief function is to make physical conditions and things intelligible or thinkable. The kinetic theory of gases, as it exists in the mind of a physicist, is pretty nearly a working model of a gas, and it enables the physicist to "see" the properties of a gas as effectively or even more effectively than he could see them in an actual working model.

A fourth method in physics is the statistical method. The best examples of the use of this method in the laboratory are, perhaps, Perrin's experimental studies of the Brownian motion and Rutherford's experimental studies of the scattering of alpha and beta rays. The statistical method as used in the kinetic theory of gases and in statistical mechanics is a purely theoretical structure and it belongs to the atomic theory, whereas by "the" statistical method we mean the laboratory study of actual erratic things and the interpretation of the observed results by the use of the theory of probability.

Every method in physics has been strengthened (in the field in which the method is really applicable) by modern discoveries. In some cases this strengthening is a clear recognition of the inapplicability of the method in a certain field, in other cases this strengthening is the clear recognition of new fields of application, and in some cases this strengthening comes from modifications of fundamental ideas which makes the foundations of the method more secure. Thus it must be counted as a strengthening of the method of mechanics to recognize clearly that the method is not applicable to phenomena which involve irreversible

or microscopic effects, Maxwell's theory has extended the method of dynamics to include the whole of electricity and magnetism (where irreversible effects are non-existent), the principle of relativity has strengthened the method of mechanics by generalizing many of the fundamental mechanical ideas and relations, even the quantum theory strengthens the mechanical method by ruling out atomic and molecular actions from its field.

Profound changes in our so-called fundamental ideas in physics have come about in recent years because of three things, namely, (a— an increasingly clear appreciation of the significance of irreversible actions in nature has led us to recognize definite limitations to the method of mechanics (Planck's dynamics), for an irreversible process is beyond the range of the mechanical method, (b— the principle of relativity has modified our ideas of time and space and has extended the idea of energy to include the idea of mass, and (c) the quantum theory has led to a recognition of the essential differences between large-scale and small-scale phenomena, between the behavior of macro-systems and micro-systems; but the changes in our so-called fundamental ideas seem in most cases to be merely formal in that these changes have been in most cases merely the elimination of what is non-essential from our fundamental ideas, although the quantum theory seems to strike more deeply.

The quantum hypothesis denies the principle of continuity as used throughout the method of mechanics. Atomic processes take place by jumps so that the idea of time as a continuous flux is brought into question, and if time as a continuous flux is objectively non-existent then the whole structure of theoretical dynamics must be purely idealistic and at best only applicable to large scale phenomena. Indeed, the atomic theory itself raises the presumption that continuous space is an idea, not a physical fact, as was pointed out by Riemann many years ago, and thus the purely idealistic character of theoretical dynamics is again indicated.

The whole of statistical mechanics, which includes the kinetic theory of gases, is a theoretical structure based upon purely mechanical postulates concerning atomic action whereas the quantum hypothesis rules out the purely mechanical conceptions of atomic action and it seems therefore that the quantum hypothesis is likely to lead to profound changes in the atomic method.

As stated above the methods of physics have remained almost wholly unchanged by modern developments, and, although the principle of continuity is in danger of being thrown out by the quantum hypothesis, the other principles of physics seem to be altered by being made more general. (a) The principle of the conservation of energy still stands, but the principle of the conservation of mass has become a part of it. (b) The principle of the conservation of momentum retains its validity in a decidedly widened field. (c) The second law of thermodynamics is untouched. Many men who hold a principle narrowly seem to feel that the principle is destroyed by a change which on careful scrutiny turns out to be only a generalization of the principle.

DEAN OF AMERICAN BOTANISTS.

In the spring of 1872, the personnel of the first scientific expedition into the then almost unknown Yellowstone National Park was encamped at Ogden, Utah, waiting for its chief to come on from the East. The youngest geologist in the party, a youth just out of college, spent his spare time collecting the plants of the region and trying, without much success, to classify them out of a manual of botany designed for the eastern United States.

When Dr. Hayden appeared and found the incipient herbarium which young John Coulter had got together, he created a new position of botanist to the expedition and put him into it. Thus did a great geologist rob his own profession to give American botany one of the foremost men in its whole history.

Twenty-four years later, President Harper was going about the country seeking whom he might devour for his new university. He found Dr. Coulter filling the posts of president and professor of botany at Indiana University, and offered him the headship of the department at Chicago. For a solid generation thereafter, until his retirement in 1925, Dr. Coulter wrote large pages in the history of American botany. He manned his department with his own graduate students; the record of their teaching and research activities justifies the use of that slightly over-worked term, impressive. He made Chicago the source of an army of competent botanists; there are a few leading botany departments in this country that do not have a Chicago graduate on their staffs. He founded and edited the Botanical Gazette, one of the foremost scientific journals in the world. He wrote and collaborated in writing in a very solid array of books. He took an active part in organizing a number of botanical and other scientific societies.

Finally, at an age when most men are content to rest on their honors, he interested his friend William Boyce Thompson in the construction and endowment of a great institute for plant research at Yonkers, N. Y., where a new technology, which may properly be called plant engineering, is being developed. It is as head of the Boyce Thompson Institute for Plant Research that Dr. Coulter spends the days of his very active "retirement."—*Science News-Letter.*

SCIENCE QUESTIONS.

CONDUCTED BY FRANKLIN T. JONES.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

QUESTIONS AND PROBLEMS.

500. *Proposed by Wallace C. Swank, Eaton Rapids, Mich.*

Explain why it is that one can "pump up" in a swing.

501. *Proposed by Paul A. Miller, Supt. Public Schools, Rolette, North Dakota.*

Our pupils have expressed an interest in superheterodyne construction, not only for regular broadcast reception, but with "plug-in" coils, or other easily changed methods, so that the 50 meter band may be received or if desired, the 3000 meter band of European stations.

Where can *reliable* construction data be secured? Data that lists reliable working parts.

I have been informed that some of the popular magazines on radio publish, at times, questionable and unreliable data—experimental—it is called.

Temporary answer—others desired.

Aero Products, Inc., 1768-72 Wilson Ave., Chicago, Ill., publish a catalog which can be recommended.

You are invited to correspond with J. L. Leban, Sales Representative, 217 Electric Building, Cleveland, Ohio, also The M. & M. Co., 500 Prospect Ave., Cleveland, Ohio, carries a complete line.

502. *Proposed by Smith D. Turner, Cambridge, Mass.*

Per pound of water passing through a hydraulic turbine, we can get more and more energy as we increase the pressure head of the water. It is proposed to place a turbine at the bottom of a well so deep that the energy obtained from each pound of water, when converted into electricity by a generator run by the turbine, will be sufficient to electrolyze a pound of water. The resulting gases, being lighter than air, may rise through an adjoining shaft to the top, where they may be burned, the water condensed, and returned down the well. The fact that the machines used are not 100% efficient will not prevent the system from working, as the well may be made still deeper than the theoretical depth, and enough additional power developed to overcome the losses due to inefficiencies. Power may be taken from the system (a) by making the hole so deep that more electricity is generated than is needed to electrolyze the water and overcome the losses (b) from the lifting effect of the rising gases (c) from the heat generated by the burning gases at the top (d) by using the resulting superheated steam in a steam engine.

Aside from the practical difficulties involved in the above system:

1) Would the system run as described?

2) If so, from what source does it draw its energy, or would it constitute perpetual motion?

3) If it would not run, and give power as described, point out the fallacy in the above reasoning.

(Will Mr. Turner send the EDITOR his present address? Thanks! F. T. Jones.)

JOHN LOVE CONTRIBUTES.

When John prepared his daily column for the *Cleveland Plain Dealer* of November 9, 1927, he did not know that SCHOOL SCIENCE AND MATHE-

MATICS would use his thunder and broadcast his questions over the civilized world.

THE BYPRODUCT.

Comment on Business, Industry and Activities in General.

By JOHN W. LOVE

After cheerfully voting against every candidate who painted his name on the sidewalk, I came down into the annual office turmoil and read that a San Diego aviator is going to dive 10,000 feet from an airplane and then open his parachute, thus maybe setting a new record for the long distance drop.

He has sublime faith in mathematics. He must watch the second hand tick off twenty-five before he pulls the cord that opens the life saver. In twenty-five seconds he should have traveled nearly two miles. Most of us would begin to wonder if our figures were right when we got beyond the fifteenth second.

There is a minority of readers of this miscellany upon whom we can depend for answers to any sort of problem. I appeal to them for solutions of the following:

503—How fast will the parachuter be going when he has dropped 10,000 feet, assuming no wind resistance?

* * *

504—How far would he have to drop before exceeding the speed record of 315 miles an hour made by the Italian aviator off Venice last Saturday?

* * *

505—What would be the weight on the parachute if it opened suddenly after dropping 10,000 feet? You will have to assume a weight for the aviator.

SOLUTIONS AND ANSWERS.

497. *Proposed by Smith D. Turner, Cambridge, Mass.*

If a piece of cork is submerged in a bucket of water and released, it will rise to the top. But if at the instant it is released, the bucket is allowed to fall freely

(a) through the air,

(b) in a vacuum

what will be the motion of the cork relative to the water?

Answer by Wallace C. Swank, Eaton Rapids, Mich.

The cork would stay put with relation to the water in either case. In a stationary body of water a submerged body is buoyed up with a force equal to the weight of water displaced less the weight of the body. However, a freely falling body has no weight, so that neither the water nor the cork would have any weight and there would be no tendency to force the cork out of the water. Since the cork and water are both heavier than air the air should have no effect.

EXAMINATION PAPERS.

PHYSICS

Massachusetts Institute of Technology, September, 1926

PART I

(Answer all questions)

1. State the mechanical units in which the following are expressed in both the Metric and English systems:
   a. Force c. Power
   b. Work d. Acceleration
   e. Density
2. A man raises a stone 1 inch with a crowbar 10 feet long. The fulcrum is 1 foot from the end of the bar.
   a. If he exerts a force of 100 pounds how much force is applied to the stone?

b. How much work does he do?

3. A ball weighing 8 ounces is thrown vertically upwards and remains in the air 8 seconds.
   a. How high does it rise?
   b. With what velocity does it strike the ground?
   c. What is its greatest kinetic energy?
   d. Where does it have its maximum potential energy?
   e. How much has it?
4. A mass of brass (specific gravity 8.50) is suspected of being hollow. It weighs 1700 grams in air and 1450 grams in water. What's the volume of the cavity?
5. What is the resistance of a 10 ohm and a 40 ohm coil connected?
   a. In series?
   b. In parallel?
   c. If 100 volts were applied to the coils as in a and b what would be the current flowing in each coil in each case?
6. What is it necessary to know in order to determine the wave length of a certain sound?
7. How can one distinguish between a real image and a virtual image? State which is produced in each of the following cases:—
   a. A convex lens with the object inside the principal focus.
   b. A convex lens with the object outside the principal focus.
   c. A concave lens with the object inside the principal focus.
   d. A concave lens with the object outside the principal focus.
   e. A concave mirror with the object inside the principal focus.

PART II.

(Answer three questions)

8. What is meant by:
   a. Coefficient of linear expansion?
   b. Coefficient of cubical expansion?
   c. Latent heat of fusion?
   d. Latent heat of vaporization?
   e. Specific heat?
   f. How much ice at 0°C. would be needed to cool 2 cubic meters of water from 90°C to 30°C? Heat of fusion of ice is 80 calories per gram.
9. If a bubble of air one millimeter in diameter at the bottom of a pond changes to a bubble one centimeter in diameter at the top of the pond how deep is the pond?
10. A transformer assumed to be 100 per cent efficient draws from a 220 volt line and runs two 11 volt lamps connected in series.
    a. If the resistance of each lamp is 10 ohms how much current is flowing in the secondary?
    b. How much current flows in the primary?
    c. How many watts does each lamp use?
11. A stone is dropped over a canyon wall and 5.36 seconds later the sound of the stone striking the bottom is heard. (Tem. 20°C.) How deep is the canyon?
12. A train starting from rest goes 44 feet during the 16th second.
    a. What is its acceleration?
    b. How far did it go in the first 10 seconds?
13. Tell how each of the following types of spectra is produced:—
    a. Continuous spectra.
    b. Dark line spectra.
    c. Banded spectra.
    d. Bright line spectra.

In a campaign against diphtheria in Georgia about 125,000 children were immunized through cooperation of the school authorities, the State board of health, and parent-teacher associations. About 50,000 of the children were treated privately. The State laboratory distributed 76,555 cubic centimeters of toxin-antitoxin and 7,650 Schick tests to determine immunity against the disease.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

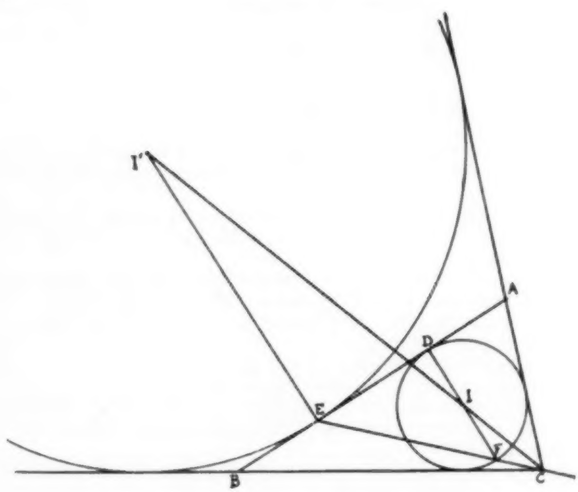
SOLUTIONS OF PROBLEMS.

976. *Proposed by Tillie Dantowitz, Philadelphia, Pa.*

Determine the locus of the vertex of a triangle, given the difference of the sides, and the radius of the inscribed circle.

I. *Solved by George Sergent, Tampico, Mex.*

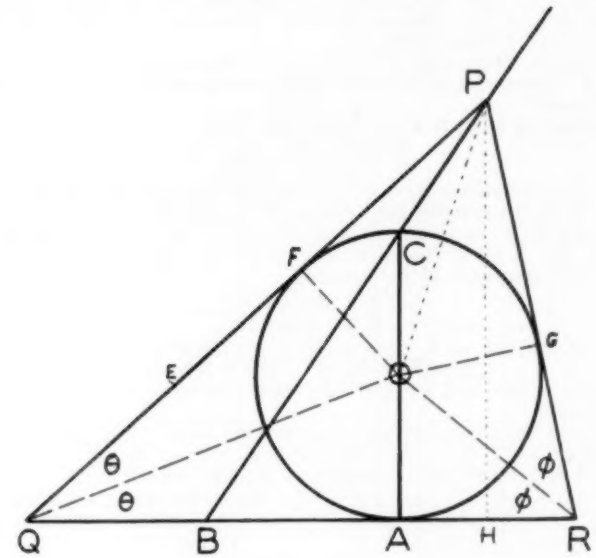
Let ABC be any triangle, I the in-center, I^1 the ex-center opposite C. Let D and E be, respectively, the points of contact of AB with the circles I and I^1, and DF the diameter of the in-circle, perpendicular to AB.



The segment DE is equal to the difference of the sides BC and AC. The vertex C is the center of external similitude of the circles I and I^1. The line EF, joining the extremities of two parallel radii, I^1E and IF, passes through the center of similitude, C. Hence the locus of C is the prolongation of the hypotenuse of the right triangle whose legs are the given difference of the two sides, and the diameter of the in-circle, perpendicular to the third side.

II. *Solved by Michael Goldberg, Washington, D. C.*

Let CA be the diameter of the given inscribed circle, and AB ($\perp$ to CA) be the given difference of the sides. Then if QB = RA, the tangents from Q and R intersect in P which is a point on the locus, for $PQ - PR = QA - RA = AB$.



Let $CA = 2a$, $AB = b$, $QB = RA = t$. Then

$$\tan\theta = \frac{a}{b+t}, \qquad \tan 2\theta = \frac{2a(b+t)}{(b+t)^2 - a^2},$$

$$\tan\phi = \frac{a}{t}, \qquad \tan 2\phi = \frac{2at}{t^2 - a^2}.$$

If the origin of coordinates is A, the equation of QP is

$$\frac{y}{x+(b+t)} = \tan 2\theta.$$

The equation of RP is

$$\frac{y}{x-t} \tan 2\phi.$$

Eliminating t from these two equations gives

$$2ax - by + 2ab = 0,$$

which is the equation of a striaght line through B and C.

III. *Solved by Bessie Green Andrews, Wichita, Kansas.*

Editor. The notation used refers to the Figure of *Solution* II.

Construct a triangle PQR about a circle of radius R, and having the difference of its sides QE. Draw diameter AC; mark $AB = QE$. Then BCP is the required locus. Draw the altitude PH.

Area of triangle $QPR = R(PG + 2AR + QE) = (PH/2)(2AR + QE)$.

Hence

$$QE = \frac{2R(PG) + 4R(AR) - 2(PH)(AR)}{PH - 2R}. \quad (1)$$

Since the triangles BCA and BPH are similar, we get

$$AB = \frac{2R(AH)}{PH - 2R}. \quad (2)$$

Since twice the area of $PRAO = R(PG + 2AR) = (PH)(AR) + R(AH)$, we get

$$AH = \frac{R(PG) + 2R(AR) - (PH)(AR)}{R}.$$

Substituting the value of AH in (2), we get for AB the same expression as given for QE in (1). Hence AB = QE. Since the point B is fixed, the required locus is the line BCP.

Also solved by *Daniel Kreth, Wellman, Iowa; F. A. Caldwell, St. Paul, Minn.; J. F. Howard, San Antonio, Texas; George Gatje, Islip, L. I., N. Y.; and the Proposer.*

977. *Proposed by I. N. Warner, Platteville, Wis.*

$$X^4+Y^4=272 \quad (1)$$
$$X+Y=6. \quad (2)$$

Editor. The solutions have been classified by types, and in the first four types only the general plan of solution is given.

I. Making a direct substitution of Y in terms of X leads to a biquadratic equation in X. Two of the roots were found by *synthetic division*, or by $F(r)=0$. The four sets of values are:

$$X=4,\ 2,\ 3\pm\sqrt{-55}$$
$$Y=2,\ 4,\ 3\mp\sqrt{-55}.$$

II. The biquadratic in X, mentioned in (I) may be arranged as

$$(X^2-6X)^2-72(X^2-6X)+512=0.$$

Factoring gives $(X^2-6X+8)(X^2-6X+64)=0$, from which the values of X can be found.

III. Squaring equation (2) and subtracting from (1) gives a quadratic in XY, $(XY^2)^2-72(XY)+512=0$. Hence $XY=8$ or 64. Solving the system with $X+Y=6$, we can find the values of X and Y.

IV. Assume $X=U+V$, and $Y=U-V$. Substituting in (2) gives $U=3$. Substituting in (1) and using the value $U=3$, gives $V^4+54V^2-55=0$. Hence $V=\pm1$ or $\pm\sqrt{-55}$.

V. *Solved by some reader from Pasadena, Calif.*

The solution was sent to the *Proposer* who relayed it to the editor. The editor desires to know who sent in the solution.

General solution.

$$X^4+Y^4=a \quad (3)$$
$$X+Y=b. \quad (4)$$

Assume $XY=c$, and solve with (4). This gives

$$X=\frac{b\pm\sqrt{b^2-4c}}{2},\quad Y=\frac{b\mp\sqrt{b^2-4c}}{2}.$$

Squaring (4) and substituting the value of $XY=c$ gives $X^2+Y^2=b^2-2c$. Squaring this result and substituting known terms gives

$$c^2-2b^2\ c+(b^4-a)2=0.$$

Hence $c=b^2\pm\sqrt{(b^4+a)/2}$. Then $b^2-4c=-3b^2\mp2\sqrt{2(b^4+a)}$. Therefore

$$X=\frac{b\pm\sqrt{-3b^2\mp2\sqrt{(b^4+a)2}}}{2}.$$

$$Y=\frac{b\mp\sqrt{-3b^2\mp2\sqrt{(b^4+a)2}}}{2}.$$

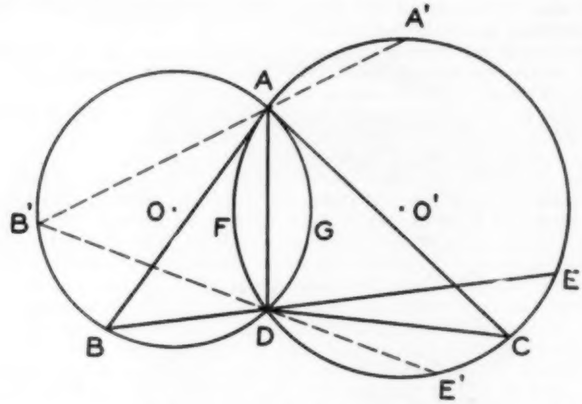
Solved by *M. Freed, Los Angeles, Calif.; J. F. Howard, San Antonio, Texas; George Sergent, Tampico, Mexico; E. de la Garza, Brownsville, Texas; J. Murray Barbour, Aurora, N. Y.; Orville Barcus, Columbus, Ohio; J. K. Elwood, Dayton, Pa.; Raymond Huck, Shawneetown, Ill.; Theodore Ligda, Oakland, Calif.; F. A. Caldwell, St. Paul, Minn.; Franklin A. Butter, Jr., San Jose, Calif.; R. E. Many, Brooklyn, N. Y.; Smith D. Turner, Parkersburg, W. Va.; George Gatje, L. I., N. Y.; Michael Goldberg, Washington, D. C.*

978. *Proposed by Nathan Altshiller-Court, Norman, Okla.*

The lines joining the points of intersection of two given circles to any point on one of these circles determine in the second circle a chord subtending at any point of the second circle an angle equal to the angle of intersection of the two given circles.

Consider the special case when the given circles are orthogonal.

Consider the case when the point taken on the first circle coincides with one of the points of intersection of the two given circles.



Problem No. 978. *Solved by Michael Goldberg, Washington, D. C.*

Let the circles O and O^1 intersect in A and D. Let AB be the tangent to O^1, and AC be the tangent to O. Then the angle between the circles is $\angle BAC$.

But $\angle DAC = \angle ABD$ (each measured by half of arc AGD),

$\angle ABD = \angle ABE$ is measured by $\frac{1}{2}$(arc AE − arc AFD),

$\angle BAD = \angle ACD$ (each measured by half of arc AFD),

$\angle BAC = \angle BAD + \angle DAC$. $\therefore \angle BAC$ is measured by arc AE.

If B is at any other point, say at B^1, then the angle at B^1 equals the

angle at B and is measured by $\frac{1}{2}$(arc A^1E^1 − arc AFD). But since arc AFD is constant, arc A^1E^1 = arc AE.

When the circles are orthogonal, then arc A^1E^1 = arc AE is a semicircle.

When B^1 coincides with A, then B^1A^1 becomes the tangent AC, and E^1 becomes A. The arc ADC is equal to the arc AE.

Also solved by *George Sergent, Tampico, Mexico; J. F. Howard, San Antonio, Texas; and F. A. Caldwell, St. Paul, Minn.*

Solved by J. Cecil Brown, Wheeling, W. Va.

I. There are 20^{20} ways that the choices may be made. There are 20! ways in which 20 numbers, all different, may be named. There are 20 ways in which the same number may be chosen by all. Therefore the probability that no two name the same number is $20!/20^{20} = 19!/20^{19}$.

The probability that all name the same number is $20/20^{20} = 1/20^{19}$.

II. The probability that the second person does not match the first is 19/20; that the third does not match either the first or second is 18/20; and so on. The continued product gives the result stated in (I).

The probability that the second will match the first is 1/20; that the third will match the second is 1/20; but that the second and third both match the first is $1/20^2$; and so on, until all 20 persons have been considered.

Also solved by *Michael Goldberg, Washington, D. C.; J. Murray Barbour, Aurora, N. Y.; R. E. Many, Brooklyn, N. Y.; and the Proposer.*

980. *Proposed by John Ankebrant, Gunnison, Colorado. For High School Pupils.*

Sacks of salt are placed end to end on a conveyor which is moving at a uniform rate of speed. A man walking in the same direction as the conveyor starts at the first sack and walks until just past the 25th sack. He then turns about and walks back to the first sack, which now is where the 25th sack originally was. How many sack-lengths did he walk?

Solved by Theodore Ligda, High School, Oakland, Calif.

Let X represent the distance that the 25th sack moves before the man overtakes it. During the same time the man walks (X + 25) sack lengths. The motion of the sack is represented by D = RT, and the motion of the man is represented by $d = rt$. Since the time of motion is the same for both we have $D/R = d/r$. But D = X, and $d = X + 25$. Therefore

$$R/r = X/(X+25). \quad (1)$$

Let us now compare the motions of the first sack and the man. The first sack moves 25 sack lengths while the man makes a round trip of (25 + 2X) sack lengths. While the distances and times are different the rates are the same as before. Hence

$$R/r = 25/(25+2X). \quad (2)$$

From (1) and (2) we get X = 17.68 sack lengths. Hence the man walked 60.36 sack lengths.

Also solved by *E. de la Garza, Brownsville, Texas; and George Sergent, Tampico, Mexico.*

PROBLEMS FOR SOLUTION.

991. *Proposed by B. F. Yanney, Wooster, Ohio.*

Divide a given right triangle by letting fall a perpendicular from the vertex of the right angle to the hypotenuse. Do the same for each of the resulting right triangles. Continue this process to the nth division. Find expressions in terms of the sides of the original triangle for the sides of each of the triangles thus formed.

992. *Proposed by Daniel Kreth, Wellman, Iowa.*

Solve by trigonometry.

$$X^3 - 10X^2 - 80000X + 100000 = 0.$$

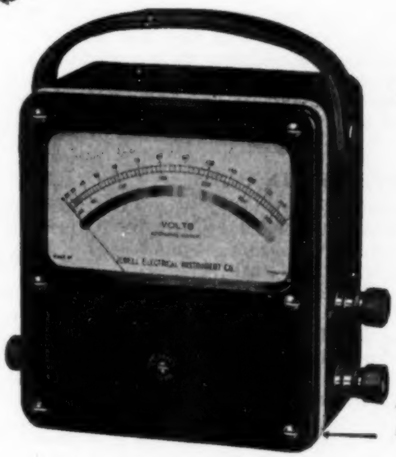
993. *Proposed by George Sergent, Tampico, Mexico.*

Determine on a line L a point X, such that the sum of the lines AX and BX equals a given line length m. Points A and B are not on the line L.

994. *Proposed by Smith D. Turner, Cambridge, Mass.* Find rational factors of $X^8 - 4X^4Y^4 + 16Y^8$.

JEWELL

A Quality Instrument



Pattern No. 172 A. C. MASTER Portable

Red Stripe

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995. *For High School Pupils. Proposed by Nathan Altshiller-Court, Norman, Oklahoma.*

Through a given point two secants are drawn to two given intersecting circles, in such a way that two of the four points of intersection of the circles with the secants are collinear with one of the points common to the two circles. Prove that the other point common to the two circles, and the other two points of intersection of the circles with the secants determine a third circle which passes through the given point.

ARTICLES IN CURRENT PERIODICALS

American Botanist, Willard N. Clute & Co., Joliet, Illinois, $2.00 a year, 50 cents a copy. The Tickseed Sunflower by Willard N. Clute. Sagebrush by Mrs. M. E. Soth. Always Something New by W. A. Bridwell. Oregon Vegetation by Mrs. M. E. Soth.

American Journal of Botany, October, Brooklyn Botanic Garden, Lancaster, Pa., $7.00 a year, 75 cents a copy. The Germination of the Seeds of some Plants with Fleshy Fruits by John Adams. The Growth and Development of Plastids in Lunularia Vulgaris, Elodea Canadensis, and Zea Mays by Conway Zirkle, Bussey Institution, Harvard University. Studies on the Growth of Root Hairs in solutions I. The Problem, Previous Work and Procedure by Clifford H. Farr. Histological Studies of Resistance in Tobacco to Thielavia Basicola by George H. Conant, Wisconsin Agricultural Experiment Station. Tomato Mosaic. Filtration and Inoculation Experiments by H. R. Kraybill and S. H. Eckerson, Boyce Thompson Institute for Plant Research, Inc., Yonkers, New York.

American Mathematical Monthly, October, Menasha, Wis., $5.00 a year, 60 cents a copy. Some Notes on Trigonometric Interpolation by Dunham Jackson, University of Minnesota. Function of Closest Approximation on an Infinite Range by W. D. Cairns, Oberlin College. The Evolutes of a Certain Type on Symmetric Plane Curves by J. B. Reynolds, Lehigh University.

Education, October, The Palmer Co., Boston, $4.00 a year, 40 cents a copy. Rousseau's Influence Upon Modern Educational Thought and Practice by Prof. K. A. Sarafian, M. A., La Verne College, La Verne, Calif. The Educational Historians Prepare to Strike Back by Frederick Eby, Professor of the History of Education, University of Texas, Austin, Texas. The Teacher as Diagnostician by Isaac Doughton, Head of Department of Education, State Normal School, Mansfield, Pa. Leadership by F. B. Riggs, A. B., Ed. M., Headmaster Indian Mountain School, Lakeville, Conn.

Journal of Chemical Education, October, Rochester, New York, $2.00 a year, 35 cents a copy. Marcellin Berthelot by Avery A. Ashdown, Massachusetts Institute of Technology, Cambridge, Mass. Students' Research Work in High-School Chemistry by Hattie D. F. Haub, Roosevelt High School, Oakland, California. Viscose Rayon by Milton J. Shoemaker, The Celon Company, Madison, Wisconsin. The Role of Mineral Salts in Animal Life by Henry A. Mattill, University of Rochester, Rochester, New York. Numerical Problems in General Chemistry by Stuart R. Brinkley, Yale University, New Haven, Connecticut. New Technic in Examinations by Veron M. Stowe, North Dakota Agricultureal College, Fargo, North Dakota.

Journal of Geography, October, A. J. Nystrom and Company, 2240 Calumet Ave., Chicago, Ill., $2.50 a year, 35 cents a copy. In the Background of the Turmoil in China by Wallace W. Atwood, President of Clark University. Spanish Ore for European Steel by W. O. Blanchard, University of Illinois. Contribution of Geography to Vocabulary by G. T. Renner, Jr., University of Washington, Seattle. A Method of Teaching Regional Geography by Ralph H. Brown, University of Colorado.

The Mathematical Gazette, G. Bell & Sons, London. March. On the Teaching of Mathematics, Prof. M. G. M. Hill, F. R. S. The Graphical Solution of the Quadratic, Prof. Alfred Lodge and Rev. J. J. Milne, M. A.

Geometrical Congruence, W. C. Fletcher, M. A. The Cubic Equation as a Relation between Complex Variables, Prof. E. H. Neville, M. A. *May.* Eclipse Calculations, An Elementary Treatment for Schools, T. T. Whitehead, M. A. Can the Range of Geometry Taught in the Schools be Widened? Prof. H. F. Baker, F. R. S. The Nature of an Algebraic Curve at Infinity and the Conic of Closest Contact at Infinity. E. H. Smart, M. A. On the Approximation to Irrational Numbers by Rationals, A. C. Health B. A. *July.* A Simple Exposition of Grassman's Methods, Prof. R. W. Genese, M. A.

National Geographic Magazine, November, Washington, D. C., $3.50 a year, 50 cents a copy. The Pathfinder of the East by J. R. Hildebrand. An Altitudinal Journey through Portugal by Harriet Chalmers Adams. Round About Liechtenstein by Maynard Owen Williams.

Photo-Era Magazine, October, Wolfeboro, New Hampshire, $2.50 a year, 25 cents a copy. On the Study of Pictures by Harold W. Cole. Testing Shutter-Speeds of Motion-Picture Cameras by Raymond V. Wilson. Photography in School and College by Arthur L. Marble.

Popular Astronomy, October, Northfield, Minnesota, $4.00 a year, 45 cents a copy. The Teaching of Astronomy by Harlan True Stetson, Harvard University. The Total Eclipse of 1927 by S. A. Mitchell. The Astronomical Fraternity of the World by David B. Pickering.

School Review, October, The University of Chicago Press, $2.50 a year, 30 cents a copy. The Evolution of Latin-Teaching by Clyde R. Jeffords, Newtown High School, New York City. The Factor of Intelligence in School Failures by Carl W. Maddocks, Supervising Agent, State Board of Education, Deep River, Connecticut. Checking Pupils' Personal Traits by E. L. Harms, Augusta High School, Augusta, Kansas.

Science, Grand Central Terminal, New York City, $6.00 a year, 15 cents a copy. October 7th, Chemistry in Relation to Biology and Medicine with Especial Reference to Insulin and other Hormones by John J. Abel, The Johns Hopkins University. October 14th, Jacques Loeb and his Period by Dr. Simon Flexner, The Rockefeller Institute for Medical Research, New York. Chemistry in Relation to Biology and Medicine with Especial Reference to Insulin and other Hormones by John J. Abel, The Johns Hopkins University. October 21st, The Gene and the Ontogenetic Process by Frank R. Lillie, University of Chicago.

Scientific American, November, New York, $4.00 a year, 35 cents a copy. "How Do They Know?" by Henry Norris Russell, Ph. D., Princeton University. Evolution of the Human Eye by W. E. Bailey. Nobility at work. Conservation or Extinction? by Dr. Leon Augustus Hausman.

Scientific Monthly, November, The Science Press, New York, $5.00 a year, 50 cents a copy. Mystery Monuments of the Marianas by Lieutenant-Commander P. J. Searles, Navy Yard, Boston, Mass. The Elephant Heads in the Waldeck Manuscripts by J. Eric Thompson, Field Director of the British Museum Expedition in British Honduras. Tropical Climatology by Dr. Alfred C. Reed, Stanford University Medical School. Entomology in Relation to Industry by Professor D. M. DeLong, Ohio State University. Fishery Products in the Arts and Industries by Lewis Radcliffe, U. S. Bureau of Fisheries.

BOOKS RECEIVED.

Our Evolving High-School Curriculum by Calvin Olin Davis, Professor of Secondary Education, The School of Education, University of Michigan. Cloth. Pages ix+301. 19.5x13 cm. 1927. World Book Company, Chicago, I.l. Price $2.00.

Interpretation of Educationa Measurements by Truman Lee Kelley, Ph. D., Professor of Education and Psychology, Stanford University. Cloth. Pages xiv+363. 19.5x13 cm. 1927. World Book Company, Chicago, Ill. Price $2.20.

Applied Physics Laboratory Manual by W. D. Henderson, Ph. D., University of Michigan. Cloth. 136 pages. 18x27 cm. 1924. Lyons & Carnahan, Chicago, Ill. Price 75 cents.

The Romance of Reality, The Beauties and Mysteries of Modern Science by Beverly L. Clarke, Ph. D., Research Fellow of the Carnegie Institution, Washington. Cloth. Pages vi+225. 13x20 cm. 1927. The Macmillan Company, New York. Price $2.25.

Algebra, Book Two by William Raymond Longley, Ph. D., Professor of Mathematics, Yale University and Harry Brooks Marsh, M. A., Head of the Department of Mathematics, Technical High School and Springfield Junior College, Springfield, Massachusetts. Cloth. Pages xi+457. 12.5x18.5 cm. 1927. The Macmillan Company, New York.

The Social Studies for Grades V, VI, VII, and VIII for use in the Public Schools, Dayton, Ohio. Curriculum Bulletin Number 5 by the Committee of the Social Studies. Paper. 427 pages. 17x25.5 cm. 1927. Printed under the authority of the Board of Education of the City of Dayton, Ohio.

Junior Exercises in Rapid Calculation by Earle Powers and Harold W. Loker. Paper 100 pages. 14.5x22 cm. 1927. Ginn and Company. Price 48 cents.

Laboratory Manual of Inorganic Chemistry and Elementary Qualitative Analysis by C. C. Hedges, Head of Department of Chemistry and Chemical Engineering and H. R. Brayton, Professor of Inorganic Chemistry in the Agricultural and Mechanical College of Texas. Paper. 233 pages. 15.5x23 cm. 1927. D. C. Heath and Company, New York. Price $1.48.

Algebra by William Raymond Longley, Ph. D., Professor of Mathematics, Yale University and Harry Brooks Marsh, M. A., Head of the Department of Mathematics, Technical High School and Springfield Junior College, Springfield, Massachusetts. Revised Edition. Cloth. Pages xi+601. 12.5x18.5 cm. 1927. The Macmillan Company, New York.

Beginning Chemistry and its Uses by Frederick C. Irwin, Head of the Department of Chemistry, The College of the City of Detroit, Detroit, Michigan, Byron J. Rivett, Principal of the Northwestern High School, Detroit, Michigan, Orrett Tatlock, Assistant Professor of Chemistry, The College of the City of Detroit, Detroit, Michigan. Cloth. Pages vii+607. 12.5x18.5 cm. 1927. Row, Peterson and Company, Evanston, Illinois.

New Type Questions in Chemistry by Charles C. Cook, Ph. D., formerly Head of the Chemistry Department, Boys High School, Brooklyn, New York. Cloth. Pages vi+91. 12.5x18.5 cm. 1927. Globe Book Company, New York. Price 80 cents.

Oxidation-Reduction Reactions in Inorganic Chemistry by Eric R. Jette, Ph. D., Assistant Professor of Chemistry, Washington Square College, New York University. Cloth. Pages xvi+152. 12.5x19 cm. 1927. The Century Company, New York. Price $1.10.

Mathematics for Grades V, VI, VII, and VIII for use in the Public Schools, Dayton, Ohio. Curriculum Bulletin Number 6 by the Committee on Mathematics. Paper. 186 pages. 17x25.5 cm. 1927. Printed under the authority of the Board of Education of the City of Dayton, Ohio.

Columbia Research Bureau Algebra Test by Arthur S. Otis, Ph. D., Editor of Tests and Mathematics, World Book Company and Ben D. Wood, Ph. D., Associate Professor and Director of Bureau of Collegiate Educational Research, Columbia College, Columbia University. Paper. Test: Form A, 12 pages. Price per package of 25 examination Booklets, with Manual of Directions, Key and Class Record, $1.30 net. Test: Form B, 12 pages. Price per package of 25 examination booklets, with Manual of Directions, Key, and Class Record, $1.30 net. Specimen set: An envelope containing 1 Test and 1 Key of each form, 1 Manual of Directions and 1 Class Record. Price 20 cents postpaid. World Book Company, New York.

BOOK REVIEWS.

Foundations of Biology by Lorande Loss Woodruff, Professor of Biology in Yale University. Pp. x+546. The Macmillan Company, New York, 1927.

This is the third edition of a text in general biology that was developed primarily for the work in introductory biology in Yale University. It has been used in many other schools. The author states that with constructive suggestions of those who have used the book in mind the book has been carefully revised and restatements have been made of certain problems which the advancement of the science during the past five years has made necessary.

The book is organized on the basis of biological principles rather than on subject matter. Plants and animals are used as they are best suited to illustrate the fundamental principles.

Physiology, morphology, taxonomy genetics and ecology are proportioned in such a way as to best serve the needs of the general student, rather than the future specialist along biological lines, although the course should form an excellent basis for future specialized work in biology.

A tried course in general biology such as this offers should be welcomed by those schools of college or normal school grade that contemplate offering a year of general biology as an introductory course.

The text deserves a wide use in classes of college grade and it offers a dependable reference work for teachers of high school pupils.

Jerome Isenbarger.

Manual of Biological Forms by George A. Baitsell, Associate Professor of Biology in Yale University. Pp. xiv+411. The Macmillan Company, New York, 1927.

This is a companion book to Foundations of Biology considered in the preceding review. It is a revision of an original work published in 1923.

While this book is intended as a laboratory guide to be used along with the Foundations of Biology as a text, it is more than a laboratory manual of directions for study. More than half of the book is devoted to descriptions of the structure and life processes of the representative animals and plants chosen, while the remainder of the book is devoted to directions for their study in the laboratory. The author believes that a text is needed for the laboratory work which supplies a detailed description of the types studied in the laboratory, gives an adequate conception of their structure and life processes, and also links up the study of organisms in such a way that, as the student progresses from day to day, he is able to get a vision of the whole field and to realize why a particular animal or plant is singled out for study.

The text furnishes just about the material that many teachers give by oral instruction in connection with the different studies in the laboratory. It forms a definite basis for quiz work on the laboratory part of the course.

While the Foundations of Biology deals primarily with principles, The Manual of Biological Forms embodies studies of specific animal forms.

Either book could be used along with other college texts. It is evident, however, that their greatest value will be realized in their use as companion texts in a year of introductory biology in college or normal school classes.

Jerome Isenbarger.

Psychological Analysis of the Fundamentals of Arithmetic, by Charles Hubbard Judd. Paper. Pp. x+122. 16.5x23.5. 1927. $1.00. The University of Chicago.

The investigations reported in this monograph were made possible by a grant from the Commonwealth Fund. The purpose of these investigations was to discover the nature and complexity of arithmetical ideas. Professor Judd believes that a recognition of these ideas will tend to modify the blind procedures which now characterize the teaching of arithmetic in the elementary school. He is of the opinion that no subject in the elementary curriculum is more in need of a complete overhauling than arithmetic.

J. M. Kinney.

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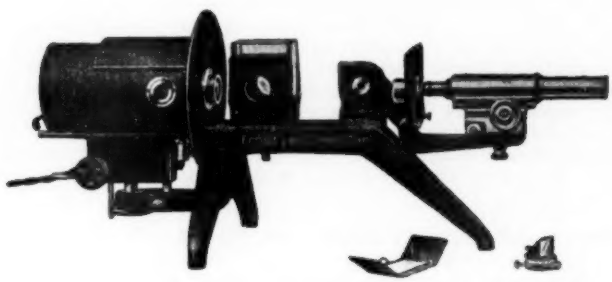

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The Laws of Living Things by Edward J. Menge, Ph. D., Director of the Department of Animal Biology, Marquette University. Cloth. 530 pages. 13.5x19.5 cm. 1927. The Bruce Publishing Company, Milwaukee, Wisconsin. Price $1.72.

In introducing this high school course in biology Professor R. A. Muttkowski points out the controlling factor in the selection and arrangement of subject matter and in the method of presentation thus: "Since the majority of high school graduates do not enter college at all, an autonomous course in biology seems not only desirable, but practically mandatory. A further reason for an autonomous course is that in the adolescent age no other subject lends itself so thoroughly to the teaching of the scientific method, to an orderly examination of facts and the formulation of conclusions based on these facts, as a general course in biology."

The features which distinguish this book from its contemporaries are: (1) in method of presentation the perch is used as the type form because working upon such a form does not cause the revulsion of feeling so often produced by dissecting a higher form, perch eggs are fertilized externally, the perch is easily obtained, ecology is emphasized, and most things learned from a study of higher forms can be learned from the perch; (2) in mechanical structure each chapter starts with a vocabulary study and most of the drawings are directly labeled. The text is well arranged for instructional purposes; the chapters are short, each is followed by a list of review questions and all technical terms used for the first time are in bold faced type. One entire chapter is used in pointing out to students proper methods for effective study. G. W. W.

The Fundamentals of Astronomy by S. A. Mitchell, Ph. D., LL. D., Professor of Astronomy of the University of Virginia and Director of the Leander McCormick Observatory and C. G. Abbott, M. S., D. Sc., Assistant Secretary of the Smithsonian Institution and Director of the Astrophysical Observatory. Cloth. Pages xi+307. 21.5x13.5 cm. 1927. D. Van Nostrand Company, Inc., New York. Price $3.00.

In writing this textbook of descriptive Astronomy the authors' primary aim seems to have been to interest pupils in the subject, for in this respect the book will certainly prove to be highly successful. The first chapter, "How to Know the Stars" takes the student at once to the wonders of the skies and points out a few of the most easily recognized stars. Anecdotes of the world's noted astronomers, and interesting facts about the delicately balanced instruments of precision housed in the great observatories keep the student fascinated while he learns the elementary principles of astronomy.

This text is based upon Professor Abbott's "The Earth and the Stars" which appeared last year and although it has been greatly improved and enlarged, it is still somewhat brief for a college course. Practically the entire book is non-mathematical and quite readable for the layman except certain topics found chiefly in the last six chapters. The chapters on the Earth, the Moon, the Sun, the Planets, Comets and Meteors, give the usual information concerning these bodies but with the addition of the recent discoveries made possible by improved instruments and more careful observation in all parts of the world. The work of solar eclipse expeditions, and relation of sun-spots to long-range weather prediction, and the evidence given by astronomy in support of Einstein's theory of relativity are timely topics in this section. The chapter on "Time, the Calender, Navigation" is especially interesting and valuable.

Five chapters in the last half of the book introduce the student to the study of the stars. The principal constellations are described and pointed out on a series of star charts. The distances to stars and how distances are measured, the information revealed by the spectroscope and the stellar interferometer, and a chapter on "The System of Our Stars" are included in this section. The last chapter "Building the Universe" gives a summary of the orderly arrangement of the inhabitants of the skies and the theory of the evolution of the universe. G. W. W.

General Chemistry, a Cultural Course based upon the texts of the late Alexander Smith by James Kendall, F. R. S., Professor of Chemistry and Administrative Chairman of the Department of Chemistry, Washington Square College, New York University. Cloth. Pages xxix+676. 20x13 cm. 1927. The Century Co., 353 Fourth Avenue, New York. Price $3.50.

This book fits into the general plan of the Century Company to produce books that will make study and the entire learning process a pleasurable occupation. In it the author recognizes that many students of general chemistry take it as a required science and do not expect to follow some occupation that demands a technical knowledge of chemistry. For that reason he has attempted throughout the book to present the subject in such a manner that it will stimulate interest and show the value of chemical laws and theories in the problems of daily experience. Frequent use is made of chemical applications in the industries and arts, and of historical incidents in the development of the subject in order to help the student realize that he is living in the "Age of Chemistry."

Although the book is labeled "A Cultural Course," in subject matter it does not differ greatly from many other good texts in general Chemistry. It is not in any sense a story book of chemistry; it is a textbook containing the essentials of general chemistry so related that the student is adequately prepared for advanced specialized courses. Modern theory built upon the recent investigations in crystal structure and radio activity is stressed and employed wherever it assists in explaining chemical processes. Valence, atomic structure and ionization theory also are emphasized. In order to give students whose instruction in chemistry will be limited to one or two semesters an opportunity to become acquainted with the wonders of organic chemistry six chapters on the compounds of carbon are included. To make room for these additions to the usual course less emphasis has been placed on the more technical phases of chemistry such as the balancing of complex equations, the solubility product law and other similar topics highly valuable for advanced work but in an elementary course largely of value in confounding freshmen. Some of the less familiar elements and compounds have likewise been omitted or very briefly described.

The text contains an unusual number of good diagrams and many halftone illustrations. Numerous references to chemical books and journal articles suggest supplementary reading. An interesting Valedictory names the world's leading modern chemists and their chief fields of work.

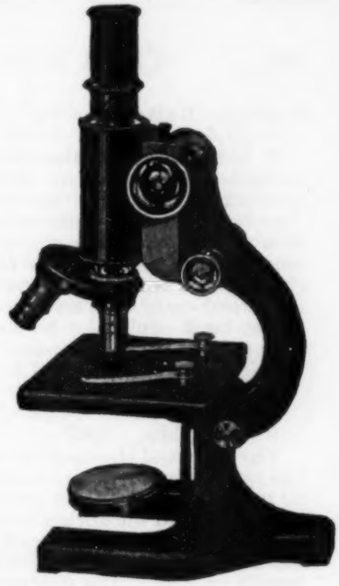
G. W. W.

Four-Place Mathematical Tables with forced Decimals compiled by F. S. Carey, M. A., Professor Emeritus in the University of Liverpool, and S. F. Grace, M. Sc., Lecturer in the University of Liverpool. Paper 39 pages. 22x14 cm. 1927. Longmans, Green & Company, 55 Fifth Avenue, New York. Price $0.40.

This is a very complete set of tables for ordinary use. In addition to the common trigonometric and log tables, the compilers have included tables of natural logs and hyperbolic functions, functions of angles expressed in radians, tables of squares, cubes, square roots, cube roots, and reciprocals, tables of physical and mathematical constants, and conversion tables —sexagesimal to centesimal, degrees to radians and radians to degrees. Flexible covers add to its convenience. G. W. W.

Four-Figure Tables by the late C. Godfrey, M. V. O., M. A., and A. W. Siddons, M. A., Late Fellow of Jesus College, Cambridge Assistant Master at Harrow School. Cloth. Pages 40. 22x15 cm. 1927. Cambridge University Press, London. American Agents, Macmillan Company.

The outstanding feature of the 1927 edition of this book is the side-index. This improvement together with the fact that each table is complete on two opposite pages provides the most convenient arrangement possible. G. W. W.



Freshman Mathematics, by G. W. Mullins and D. E. Smith. Pp. vi+386. 15x21.5 cm. 1927. $3.00. Boston: Ginn.

It is becoming fashionable in recent years to offer students entering college courses which are designed to give a general view of the mathematics following the elementary algebra and geometry of the high school. This book presents material for such a course. This material is arranged in a definite sequence of topics which shall serve as an introduction to mathematics which may be considered to be on a college level. There are chapters on logarithms, trigonometry, analytic geometry, the calculus, numerical equations, and practical mensuration.

The book could also be used in high schools offering third and fourth year courses in mathematics. J. M. Kinney.

Hygiene and Sanitation, The Essentials of Modern Health Care, by Jesse Feiring Williams, M. D., Professor of Physical Education, Teachers' College, Columbia University. 344 pages. W. B. Saunders Company, Philadelphia. 1927.

The object of the book as stated by the author is to secure in brief form the essentials of hygiene and sanitation as developed in modern times, and to make this instruction serve the needs of teachers and students. Those who have read the author's earlier work, Personal Hygiene Applied, will be anxious to read this new book as it is even more specific in the treatment of the applications of the principles of practical hygiene. Each chapter is a health treatise. The different phases of personal health which are taken up are care in modern times; care of one's self; care of expectant mothers; care of babies and young children; care of children; care of the aged, infirm and invalid; care in disease, and care of the home. The civic phases of the problem discussed are care in the factory; care in the city, state and nation, and care on an international basis. The work is scientific and practical. While it is suited to the use of mature students in classes in hygiene, it is also useful to the general reader and in this use it should prove valuable, especially to parents and teachers as it gives a scientific basis for health care.

The book should prove a most valuable aid in the movement toward the teaching of modern health ideas and ideals in the schools.

Jerome Isenbarger.

The Unity of Life. A book of Nature Study for parents and teachers by H. R. Royston, M. A. Cloth, size 13x19 cm., 281 pages, with 16 plates and 23 diagrams in the text. Published by the World Book Company, Yonkers on the Hudson, N. Y. 1926, cost $2.00.

This book was written primarily for teachers and parents interested in imparting some knowledge of nature study to young people, and especially to help with the important topic of evolutionary biology. The discussion is clear and logical and the facts are presented in a way that holds the attention.

We can best indicate the general content of the book by listing some of the chapter titles. Particularly interesting are these: "Life"; "Marriage among Plants"; "Marriage among Animals"; "The Origin of Life"; "Colour in Animals and Plants"; "Darwinism." Teachers not well grounded in the evolutionary principles of life will find this book very helpful. W. W.

New Civic Biology, by George William Hunter, Ph. D., Professor of Biology, Knox College, Galesburg, Illinois. Cloth. 13x20 cm., 448 pages, illustrated with numerous figures and plates. Published by the American Book Company, 1927.

Professor Hunter is the author of several science texts for public school use which have met with much favor. This book is intended to meet the views set forth in the report of the Committee of National Education Association on the "Reorganization of Science in Secondary Schools." The study of problems is made the basis of the work. There are "laboratory suggestions" for each problem, the author's diction is clear and understandable to students of the tenth grade. We think the choice of problems for discussion and study is good and such as will appeal to the interest of high school students. The book is altogether commendable and no doubt will be successful in class use. W. W.

Plane Geometry, by D. M. Bernard, Head of the Department of Mathematics, Duval High School, Jacksonville, Florida, with the Editorial Cooperation of A. W. Philips, Head of the Department of Mathematics, Kansas State Teachers College of Emporia. Pp. xiv+334. 14x20 cm. 1927. $1.24. Richmond: Johnson Publishing Co.

There are two features of this book which are worthy of notice.

1. The method of proof of a theorem is given before the formal proof. In Book I the method of proof and the proof are given for every proposition. In the following books the proofs are frequently omitted.

2. At the beginning of each book is found a chart of all the figures used in the proofs of all the main propositions in that book. The charts may be used to give the pupil a view of the subject matter of the book, to show how the subject is developed, to drill on the statements of theorems, and for review purposes. J. M. Kinney.

A Debate on the Theory of Relativity, by R. D. Carmichael and H. T. Davis, Favoring the Theory, W. D. MacMillan and M. E. Hufford Opposing the Theory. Pp. viii+154. 13.5x19.5 cm. 1927. $2.00. Chicago: Open Court.

This book presents in a scholarly way and yet in language that may be understood by the layman, the opposing views of the two schools of scientists in regard to the Theory of Relativity. J. M. Kinney.

Mathematical Statistics, by H. L. Rietz, Professor of Mathematics, The University of Iowa. Pp. xi+181. 13x19.5 cm. 1927. $2.00. Chicago: Open Court.

This is the third book of the series of the Carus Mathematical Monographs. It is sponsored by the Mathematical Association of America. Its aim is to make available statistical theory. The author states that during the preparation of the manuscript numerous books on statistical methods appeared and that at one time he thought that probably they had covered the ground in such a way as to accomplish the main purpose of the monograph.

However, he found that they have not, in general, gone far enough in setting forth the nature of the underlying theory in certain highly important methods of statistical analysis. This theory has been emphasized in this monograph and some of the recent advances in mathematical statistics have been discussed.

Parts of this book may be read by those who have had little college mathematics. The larger part of it, however, is designed for readers of a certain degree of mathematical maturity, and presupposes an acquaintance with the elementary calculus and the elementary principles of probability.

J. M. Kinney.

Plane Trigonometry with Tables, by M. A. Keasey, M. A., G. A. Kline, M. A., and D. A. McIlhatten, B. A. Pp. 130. 16x24 cm. 1927. $1.28. Philadelphia: P. Blakiston's Son and Company.

The authors claim to have presented this course in trigonometry as required in modern engineering. There are numerous problems.

J. M. Kinney.

See Page 903

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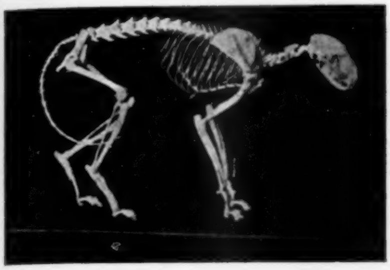

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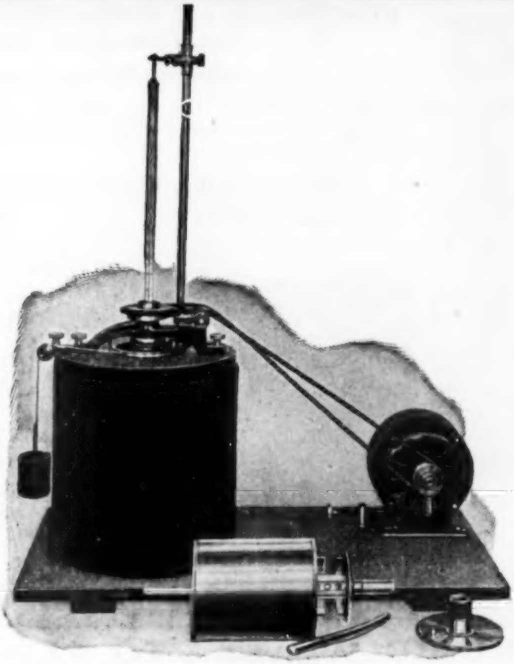

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